CONSTRUCTION PRODUCTIVITY
– AN INPUT-OUTPUT APPROACH

Any figure that looks interesting is probably false.

CSO House Motto

CONSTRUCTION PRODUCTIVITY
– AN INPUT-OUTPUT APPROACH

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ABSTRACT

This Thesis describes an approach to the development and testing of a model that can compare construction performance across time, space, and economic system. Labour and capital productivity measures as well as the multi-factor approach were evaluated. Capital productivity alone, as a 'pure' financial ratio, appears able to deal with the key problems posed by indexation, to deal with inflation for time-series comparisons, and fluctuating currency exchange rates, for international comparisons.

The major flaws with traditional capital productivity measures, particularly the problems inherent in valuing the 'capital' employed in a given industry or sector, are discussed and the model is developed to meet the objections. The notion of capital productivity employed in the model, while in computational terms similar to the traditional approach, is different in philosophical terms. Thus instead of than attempting to 'value' the capital employed in the productive process, the cost of capital 'sunk' is valued making allowance for notional depreciation based on the balance of the different types of assets employed. The discount rate emerges by counterpoising the discounted value of anticipated future profits against the historic cost of investment sunk into the current stock of capital goods.

There are problems specific to construction, in particular the incidence of *off-site* prefabrication and plant hire, which tend to make traditional capital productivity largely irrelevant to the construction process. An input-output framework is used to examine the productivity involved in the total building process as opposed to the *on-site* activities. In addition, the problems of incompatibility across economic systems manifested in such issues as differential rates of indirect taxation *etc.*, is allowed for by adjusting the price levels from market prices to 'eigenprices' an input-output based approach.

The resulting model is tested via an inter-industry time-series Case Study of the UK over the period 1948 to 1990 using six broad industrial groupings. The strengths and weaknesses of the approach are discussed in the light of the Case Study results.

KEYWORDS

Economic efficiency, Capital productivity, Input-output analysis, Linear algebra
National income statistics, Errors in numerical models.

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LIST OF ABBREVIATIONS

BSO	Business Statistics Office [of the Department of Trade and Industry]
CSO	Central Statistical Office
DLO	Direct Labour Organization
DoE	Department of the Environment
DTI	Department of Trade and Industry
EC	European Community
ECERU	European Construction Economics Research Unit
EFTA	European Free Trade Association
EMS	European Monetary System
ERM	Exchange Rate Mechanism
GDP	Gross Domestic Product
GNE	Gross National Expenditure
GNP	Gross National Product
GNY	Gross National Income
GSS	Government Statistical Service
HMSO	Her Majesty's Stationery Office
IMF	International Monetary Fund
NACE	General Industrial Classification of Industries within the EC
NEDO	National Economic Development Office
OPEC	Organization of Petroleum Exporting Countries
OECD	Organization for Economic Co-operation and Development
RICS	Royal Institution of Chartered Surveyors
SET	Selective Employment Tax
SIC	Standard Industrial Classification
UK	United Kingdom
USA	United States of America
USSR	Union of Soviet Socialist Republics
VAT	Value Added Tax

PROLEGOMENA:

RESEARCH PHILOSOPHY

The criterion of the scientific status of a theory is its falsifiability, or refutability, or testability.

Karl Raimund Popper

0.1: INTRODUCTION

Before commencing this study, some consideration ought to be given to its underpinning in terms of research philosophy. This aims to set the Thesis in the context of accepted scientific research methodology. The conclusions on the efficacy of the model proposed and tested will be judged against the criteria laid down in this Prolegomena.

0.2: THE DEDUCTIVE MODEL

0.2.1: Introduction

The dominant methodological approach, used in both the natural and social sciences, is that associated with Karl Popper (1989, 1990), certain key elements of which can be traced to earlier philosophers. The key to his method is the generation of *falsifiable* hypotheses. Thus, to be of any use, the hypotheses must be amenable to testing and possible to refute (Popper, 1990):

> *A scientist, whether theorist or experimenter, puts forward statements or systems of statements, and tests them step by step. In the field of the empirical sciences, more particularly, he constructs hypotheses, or systems of hypotheses and tests them against experience by observation or experiment.*

0.2.2: Scientific objectivity

The definition of scientific objectivity warrants some discussion. Popper (1990) takes a similar position to Kant in that an objective theory must be one that is justifiable independently of anybody's whim (if they are in possession of their reason!). Since Popper takes the view that scientific theories are never fully justifiable *albeit* testable, then the objectivity of scientific statements depends on the extent to which they can be *inter-subjectively* tested.

0.2.3: Testing a theory

This inter-subjective testing follows from Popper's (1969) notion of inter-subjective criticism *via* mutual rational control by critical discussion. Popper (1990) suggests four different lines along which this stringent and continual testing of a theory could proceed:

i) The logical comparison of the conclusions, in themselves, to test for the *internal consistency* of the system.

ii) The investigation of the logical form of the theory to decide if it can be classified as empirical or scientific theory or if it is merely *tautological.*

iii) The comparison with other theories to assess if it presents anything new or *innovative*, on the assumption that it survived the various tests.

iv) The testing of the theory, by way of *empirical applications* of the conclusions that may be derived from it.

In essence Popper's view that science progresses by the continual testing of existing theories and when falsified their subsequent replacement by sounder theories. Thus the long established Newtonian theory of dynamics was modified by James Clark Maxwell's theory of electromagnetism, and later by Einstein's theory of special relativity (Penrose, 1989).

0.3: THE PARADIGMATIC MODEL

0.3.1: Introduction

Thomas Kuhn presents an alternative view of the mechanism of scientific progress. Kuhn (1970) argues that the famous 'classics' of science, such as Aristotle's *Physica*, Ptolemy's *Almagest*, Newton's *Principia* and *Optiks*, and Franklin's *Electricity*, all served (with little challenge) as the legitimate methods of research for successive generations of practitioners.

0.3.2: Classic paradigm theories

Kuhn (1970) attributes this to the fact that the 'classics' shared two essential characteristics:

a) Their achievement was innovative and unprecedented and thus they could attract an enduring group of adherents away from competing modes of scientific activities.

b) Simultaneously the approach was sufficiently open-ended thus leaving a wide range of problems for this group of practitioners to resolve.

Thus the approach must be sufficiently successful to attract adherents but not so successful that nothing is left to be resolved so that the theory will be developed.

Kuhn (1970) says that:

> *Achievements that share these two characteristics, I shall henceforth refer to as 'paradigms'...*

The study of a *paradigm* prepares a scientist to join a particular community who will be committed to the same 'world view' encompassing rules, standards, and values. Thus once a paradigm is set up and a community established around it, a period follows, characterized in Kuhn's view as 'normal science'. It is argued by Kuhn that, in contrast to Popper's view of continual testing, most scientific research does not attempt to test the paradigm theory. Instead the scientist will seek to exploit the theory, to use it, to extend it, and to apply it. Thus Kuhn (1970) asserts that:

> *In no sense, however, are [such] tests directed to current theory. On the contrary, when engaged with a normal research problem, the scientist must premise current theory as the rules of the game.*

This gives to the established theories, a degree of immunity from refutation.

0.3.3: The focus of scientific investigation

Kuhn (1970) then goes on to identify three foci for factual scientific investigation:

i) First, there is the **determination of significant facts**: the class of facts shown by the paradigm to be particularly revealing of *"the way of nature."* Because of the use made of such facts for the solution of problems, they are considered worthy of determination. This applies both in terms of attaining more precision and in widening the situations where they can be used. Facts of this type include: boiling points, electrical resistance and wave lengths.

ii) Second, there is the **matching of facts with theory**: a smaller class of factual determinations that involve facts without much intrinsic interest but whose results can be directly compared with the paradigm theory. This includes the highly mathematical theories that are not directly accessible to the real world, such as the few parts of Einstein's general theory of relativity that is verifiable by empirical observation.

iii) Finally, there is the **articulation of theory**: empirical work aimed at advancement of the paradigm theory, the resolution of ambiguity, and the solution of problems identified by the paradigm theory. Kuhn (1970) deemed it the most important area. It aims at the determination of:

   a) physical (universal) constants
   b) quantitative laws,
   c) qualitative aspects of nature's regularity.

The physical constants would include, within the natural sciences, such matters as the universal gravitational constant, itself subject of many refinements from Newton to Cavandish and beyond. Examples of the quantitative laws include Boyle's Law relating gas pressure to volume, Coulomb's Law of electrical attraction, and Joule's formula relating heat to electrical resistance.

Kuhn's view is essentially subjectivist in that he argues that data, in the usual sense, cannot establish the superiority of one paradigm over another because data themselves are perceived through the 'world view' of one paradigm or another. This gives the paradigm theory their degree of resistance to falsification.

0.3.4: Scientific revolutions

It is pertinent to ask; how a paradigm theory is ever discarded, given the above? Kuhn (1970) suggests that a paradigm is only replaced when there is a better paradigm to take its place; mere falsification is insufficient. This process of replacement commences with the discovery of *anomaly.*

> *Discovery commences with the awareness of anomaly, i.e., with the recognition that nature has somewhat violated the paradigm-induced expectations that govern normal science. It then continues with a more or less extended exploration of the area of anomaly. And it closes only when the paradigm theory has been adjusted and so that the anomalous has become the expected.*

Kuhn sees the abandonment of a paradigm and its replacement as a process of 'scientific revolution' with clear parallels to political revolutions. Scientific revolutions occur with a growing awareness among the scientific community that the existing paradigm has ceased to function adequately in the exploration of an aspect of nature to which the paradigm itself had previously led the way. This is triggered by *crisis* and the emergence of new theories.

0.4: SUMMARY

Popper's view of scientific progress is essentially an ideal to work towards, *i.e.* how things *ought* to be done, while Kuhn's model of scientific revolutions could be seen as representing reality, *i.e.* how things really *are* done. Popper's approach is more dependent upon *objectivity* (*i.e.* theories must be suitable for *inter-subjective* testing).

By contrast, the situation outlined by Kuhn is much more *subjective* in that only the *inter-subjective* criticisms likely to be taken seriously will be from within the paradigm theory and couched in its terms, values, and prejudices.

Stewart (1979) gives a brief coverage of the application of such approaches. He concentrates on the distinctive features of economic data. The key issue here is the difference between the physical and the economic sciences when it comes to the utilization of statistical predictions given the subjectivity of most economic decision making. It is often argued that, while individual decisions are essentially subjective, *mass* decisions can be predicted statistically (Stewart, 1979).

The relationship of the model, outlined in Chapters 2 to 6, to the traditional approaches to productivity measurement will be considered in Chapter 10. This will set the research in the context of contemporary theory to assess its philosophical justification.

CHAPTER 1:

INTRODUCTION

Britain's economic malaise stems largely from its productivity problem, whose origins lie deep in its social system.

R.E. Caves and L.B. Krause

This Chapter outlines the motivation for studying productivity and gives details of the framework of research. The key problems of measuring construction productivity are discussed.

1.1: MOTIVATION

One of the few issues that will unite economists of different persuasions concerns the importance of *productivity* in the use of resource inputs – for example Bowen (1984) asserts that:

> *Productivity performance is perhaps the best single indicator of an economy's vitality.*

It has been frequently cited that, originally Britain and subsequently the United States, gained economic superiority on the back of productivity growth. See Denison (1967) for a discussion on divergence of growth rates. More recently Japan and the Federal Republic of Germany have emerged as the strong economies within the OECD group in the 1970s and 1980s. It is often argued that this strength is underpinned by productivity growth. See Thurow (1986) and Pratten (1985) for discussions of this issue on the USA and the UK respectively.

The measurement of productivity growth first came to the fore following the second world war. At this time there was full employment in the western economies. Clearly, if all resources were full occupied, productivity growth must be seen as a precondition for increasing output. The full employment of the 1950s and 1960s gave way first to the slump of the 1970s, and subsequently to the mass unemployment and faltering growth of the 1980s and the recession of the 1990s. Over this period attention shifted towards competitiveness and the need to keep unit costs down to stay in business (Lowe 1987e).

This is particularly important for the construction industry. For example, in the United States, over the period 1977-83, not only did labour productivity growth fail to match that achieved in the manufacturing and other service industries, but it actually fell. This decline confounded many commentators. Construction, an industry once near the top of the labour productivity 'league table', experienced declining productivity.

Industry	Rate of growth % per annum		Output per hour of work $US1983 prices
	1948-65	1977-83	
Agriculture and fisheries	5.0	1.4	11.34
Mining	4.3	-1.1	22.65
Construction	3.4	-2.2	11.65
Non-durable manufacturing	3.3	2.0	21.21
Durable manufacturing	2.8	1.8	21.43
Transportation	3.1	-1.6	17.73
Communications	5.4	3.5	50.07
Utilities	6.3	-0.9	46.24
Wholesale trade	3.2	1.2	23.23
Retail trade	2.6	0.8	11.70
Finance, Real Estate, etc.	2.0	-0.4	49.70
Services	1.2	0.3	11.38
Private Business Economy	3.3	0.8	18.72

Table 1.1.1: Industrial (labour) productivity in the United States

Source: Thurow (1986)

By 1983, its labour productivity was barely ahead of agriculture ¶ (Thurow, 1986). as illustrated by Table 1.1.1 above. It can be argued that the importance of construction is more than its share of gross domestic product (*circa* 6.5% for the USA) would suggest. This is because of its critical forward linkages to other industries via the production of capital items, Thurow (1986) attributes 13% of the total comparative decline in US productivity to poor performance by construction.

Similar trends have been observed in the UK, although **absolute** as against **comparative** falls in labour productivity within construction have generally only occurred after marked downturns in the economy (Lowe, 1988). A notable example of this is the slump of 1974, following the oil price explosion, in the aftermath of the Arab-Israeli war. Another example occurred in 1980 to 1981, following the second oil price 'hike' and domestic economic experimentation characterized by dramatic cuts in public sector construction and higher interest rates.

¶ While agriculture has the image of a low productivity sector, it is fair to point out that it consistently shows the highest sectoral multifactor productivity growth in the US (Dertouzos, 1989).

1.2: OBJECTIVES

This Thesis is concerned with the development and testing of a model suitable for *comparison* of construction productivity across time, space, and economic system:

i) Time-series comparisons: this is concerned with assessing change in a given industry over time. This is a useful common yardstick to assess comparative and absolute performance.

ii) Inter-industry comparisons: this will involve evaluation of the construction industry in a particular country compared with other industries in that country, *e.g.* the UK construction industry against the UK steel industry. If the productivity gains in construction do not match those in other industries, it is likely that the costs of construction products will rise in real terms by comparison with the economy as a whole. Thus either construction will absorb an ever increasing share of Gross National Product (Harvey, 1981) or, more likely, the relative importance of construction within the economy will decline (Bon, 1991) (Bon & Pietroforte, 1990) (Lowe, 1986a). This could lead to a fall in new building with more firms and households making do with existing properties.

iii) Intra-industry comparisons: this involves the evaluation of relative performance within a given industry — for example, the building versus the civil engineering sections of construction, or the contractual sector against the direct labour sector. The latter were the subject of many exchanges in both the trade literature and academic journals in the UK throughout the late 1970s and the early 1980s. See, for example, O'Brien (1976), Sugden (1978), and Lowe (1986b). In addition to the above, comparison between companies and groups is important although beyond the immediate scope of this Thesis.

iv) International comparisons: it is of relevance to assess the relative performance of the domestic construction industry against that of other economies if there is, or is likely to be, any significant interaction. The construction industry, at least in Europe, remains probably the least international of all sectors (Whitworth & Lowe, 1988). There are definite signs that this situation is unlikely to be sustained much longer with the moves to a single European market after 1992. The growing interest of the Japanese and Korean contractors in the European market and the massive investment of the Japanese firms in the field of automation and robotics for construction is relevant here (Lowe, 1990b).

Any attempt to analyze construction across time, or across national borders, and economic systems is liable to fail due to lack of comparability in terms of price levels, *etc.* This might apply to problems of establishing a suitable price base for time-series analysis. Equally there is a problem due to instability of currency exchange rates for international comparisons. This applies, even leaving aside the question of conversion problems, affecting non-'hard' currencies such as those of the emerging market economies of Eastern Europe and the Third World.

Even in situations where this can be overcome by reliance on pure financial ratios, such as proportion of gross domestic product absorbed, or return on capital invested, there are still residual doubts about the validity of the comparison.

The Thesis should cope with three specific problems shown above:

1. The problem of indexation to take account of changing price levels. This is particularly marked in periods of high and fluctuating levels of inflation. It is liable to be of particular concern if 'noise' stemming from errors in the price/cost indices is sufficient to swamp, or at least to mask, the real movements in productivity taking place.

2. The problem of fluctuating exchange rates between currencies can make any international comparison highly suspect unless the currencies concerned are firmly 'tied' together as, for example, those within the Exchange Rate Mechanism (ERM) of the European Community's European Monetary System (EMS)¶. The problem will be even more marked for the non-convertible currencies of Eastern Europe and the Third World.

3. The problem of differential price levels within economic systems, either due to fundamental differences in the economic structural or due to factors such as the incidence of indirect taxation and/or subsidies.

The model is intended to be able to cope, at least partially, with the problem of structural differences. It should also eliminate the use of currency exchange rates and make as little use of index numbers as possible. This will minimize the impact of 'noise' within the calculations.

1.3: OUTLINE OF THESIS

The Thesis employs as its unifying principle the view that the economy can be represented in terms of inputs and outputs. It is based, to a large extent, on the approach developed by Wassily Leontief (1941).

The analysis commences in Chapter No 2 with a critical discussion on the importance of productivity as an indicator of economic efficiency. This is followed by an outline and review of the various definitions of 'productivity'. Each is assessed against the specific objectives of this study as specified above. Here, capital productivity is selected as the only approach currently available coming anywhere near to meeting the criterion of a method free from the problems imposed by index numbers and currency exchange rates.

¶ Even here the margin permitted for fluctuation within the ERM – particularly the broad range within which Sterling has been accommodated – makes this slightly suspect.

The next Chapter will deal with the main theoretical and practical difficulties involved with the use of capital productivity. In particular the Austrian and post-Keynesian critique of the fundamental underpinning of capital productivity will be considered and a reformulation of capital productivity will be presented which goes some way to meeting the above objections.

A particular problem concerning the use of capital productivity in construction concerns the impact of off-site prefabrication and plant hire. Thus a fair proportion of the capital employed in the construction process is classified not to construction, but to manufacturing or banking and finance. Since the construction Class within the Standard Industrial Classification (CSO, 1979) is confined to the *on-site* activities, any continuation in the trend towards the use of manufactured components and prefabrication will render the site-based activities of lesser importance.

The approach to dealing with this problem is to examine the productivity of the total product instead of confining the exercise to the on-site activities as covered by the SIC classification. This is accomplished in Chapter No 4 by means of the input-output framework as developed by Wassily Leontief (1941) to identify direct and indirect inputs into the construction process.

There is a problem of varying price levels between different economies and economic systems caused by such mundane factors as differential levels of indirect taxation. This is tackled, in Chapter No 5, by using 'eigenprices' — an approach developed by Francis Seton (1985). The framework of Seton's methodology is outlined and the model adapted to suit the specific needs of this Thesis is presented in terms of algebraic and matrix formulation.

The final model selected is then summarized in Chapter No 6 with references to the analysis in the previous four Chapters.

The problems involved with data collection and in particular the suitability and reliability of published sources of macro-economic statistical data are considered in Chapter No 7. While, this will be based, to a large extent, on the situation pertaining in the UK; the conditions in other countries are alluded to where appropriate.

The model developed according to the above specification will be tested in Chapter No 8 by the application of a time-series and inter-industry Case Study of the UK over the period 1948-1990. This is compared with more conventional approaches.

The Case Study employs a six-way classification of the UK economy based on the ten divisions in the 1980 version of the Standard Industrial Classification [SIC] using the following industrial groupings ¶ (CSO, 1979):

Agriculture, Forestry, and Fishing	(Division 0)
Energy and Water Supply	(Division 1)
Manufacturing	(Divisions 2, 3, & 4)
Construction	(Division 5)
Distribution, Transport, and Communication	(Divisions 6 & 7)
Banking, Finance, and other Services	(Divisions 8 & 9)

An estimated valuation of the 'capital stock' within each of the above groupings is calculated following the above formulation. Productivity figures, for each, are presented in both conventional and input-output form. The productivity measures are reformulated in 'eigenprice' form and the results are recalculated. The trends are compared and analyzed.

¶ It would have been better to avoid using the term *industry* in this context particularly in the case of construction. The term *sector* better describes the construction process which is based on several different industries. Lange & Mills (1979) argue the case that *"construction is not a single activity, but a group of activities loosely related to one another by the nature of their products, technologies, and institutional settings"*. The term *industry* is used in this Thesis to avoid confusion with the very different usage of *sector* in the UK National Accounts.

The reliability of the model as used in the Case Study is critically evaluated in Chapter No 9 and potential sources of error are highlighted.

Finally, Chapter No 10 presents the general conclusions on the factors identified in the Case Study and the overall conclusions on the model. The Chapter also outlines suggestions for further work both in terms of further testing and refinement of the model, also potential for more fundamental developments.

Details of the methodology and assumptions made in the Case Study are presented in the Appendices. Appendix No 1 covers the 'input-output' tables as used in the model. Appendix No 2 deals with the 'inputs' to the model, the investment and capital employed in each industry. Appendix 3 is devoted to the 'output' side of the model, especially the profits earned. Appendix 4 details the calculation of the profitability ratios.

Appendix No 5 presents a four country international comparison of the eigenprice structure as identified in Chapter No 4. Appendix No 6 gives background information on the collection and poublication of official statistics in the UK. Finally Appendix No 7 lists the symbols and variables used in the Thesis.

CHAPTER 2:

PRODUCTIVITY

Economic efficiency consists of making things that are worth more than they cost

J. Maurice Clark

This Chapter covers the literature on the traditional approaches to productivity measurement. The main single factor measures, labour productivity and capital productivity, are outlined and evaluated along with total factor productivity measurement. Capital productivity is selected as best meeting the requirements specified in the previous Chapter.

2.1: DEFINITION

2.1.1: Introduction

The unusual state of consensus that exists among economists regarding the importance of productivity growth predictably breaks down when it comes to the question of how productivity should be defined. 'Productivity' is usually associated with economic *efficiency* in the use of the various factors of production. This can, however, take one of two distinct meanings (Lowe, 1987b):

(a) **Productive efficiency**, which is concerned with using inputs to the general aim of minimizing unit costs of production. This relates, in essence, to the inter-firm, inter-industry, international and time-series comparison approach outlined in Chapter 1 ¶.

(b) **Allocative efficiency**, which relates to the distribution of scarce factors and resources available throughout the various productive units within the economy. The aim may be assumed to be to approach as near as possible to Pareto optimality. Pareto optimality is the situation where it is impossible to make anyone better off by redistributing resources without making someone else worse off (Brown & Jackson, 1982) §.

The latter definition relates to welfare economic considerations. It is largely the concern of central and local government plus pressure groups. It covers such areas as environmental protection and pollution control, and resource allocation. The former definition, by contrast, is more generally relevant to the direct concerns of individual companies and industrial groups.

¶ Productive efficiency is only relevant in *comparative* terms such as firm *versus* firm or industry *versus* industry, and it has little meaning in absolute terms.

§ Allocative efficiency, by contrast, has relevance in *absolute* terms in terms of approaching an ideal such as Pareto optimality.

2.1.2: Measures of productivity

Productivity, in this Thesis, is assumed to represent a measure of the efficiency of the productive process in turning **inputs** into **outputs**. 'Inputs' in this context refer to the *primary* inputs: labour and capital ¶, as opposed to *intermediate* inputs such as materials, components, energy, transportation, and also professional and financial services *etc.* 'Outputs' here may be taken to represent the financial value of the production, either in the form as of gross output or net output (value added).

2.2: SINGLE-FACTOR MEASURES OF PRODUCTIVITY

2.2.1: Labour productivity

Labour productivity is probably the most widely-used yardstick of operational efficiency. This state of affairs has, in all probability, little to do with its merits, as pointed out by Rendall and Wolf (1983):

> *...but simply reflects the difficulty or impossibility of obtaining numerical values of the other determinants of productivity.*

Much of the literature appears to operate on the (unstated) assumption that productivity **is** labour productivity. Considerations of productivity often follow a discussion of labour inputs (Metcalf & Richardson, 1984). In the specific case of the UK construction industry, most reviews have used labour productivity uncritically as Harvey (1981). Sometimes, it is used with caveats regarding problems of measurement, as with Hillebrandt (1984).

The simplest measure is average labour productivity. In effect, this represents a ratio of output per employee:

¶ In the case of contractual operations, land would not be deemed as a primary input, although for speculative development it could be included. This analysis is based on the assumption that there are two primary factors of production: Labour and Capital.

$$\text{Average labour productivity} = \theta / L \tag{2.1}$$

where: θ = output
L = labour employed

Both numerator and denominator give some problems in formulation. To be meaningful in this context, 'output' (θ) should be presented in 'value added' form, net of all intermediate inputs. Unfortunately most of the best sources are presented in gross format (Sugden, 1978). The measure for θ must be in constant price terms giving rise to problems of indexation to cover fluctuating price levels. Equally the quantification of labour employed (L) may present problems. Most commonly this is taken as the average number of operatives employed during a given year or as the number of operatives plus administrative, professional, technical and clerical staff ¶.

The simplicity of the above approach and the relative ease of availability of suitable data has lead to its widespread use and frequent misuse as for comparisons between contractors and direct labour organizations. See Sugden (1978) and Lowe (1986a) for a discussion of these issues.

Clearly, average labour productivity, as formulated above, is little more than a measure of the labour intensity of the production process and says very little about the economic efficiency of that process.

Labour productivity is, nearly always, improved by substituting another factor for labour - usually either plant (capital) or prefabricated components (materials). This substitution may or may not result in better use of resources or cheaper costs of production. Substitution will generally be of benefit only if one of the following applies (Lowe, 1987e):

¶ Measures of the labour input can also take the form of output per operative hour, index of labour cost *etc.*

1. The factor substituted (*e.g.* capital) is cheaper than the factor replaced (*e.g.* labour) thus leading to cheaper unit costs of production.

2. The factor being replaced is scarce or at least unreliable in supply.

3. The speed of production can be markedly improved leading to savings on overheads, preliminaries, *etc.*

The fundamental problem from the specific view of the construction industry is the extent to which subcontracting — particularly labour-only subcontracting — results in reduced direct employment of operatives and staff by many contractors. It should not give problems for the 'macro' productivity measures, employed in this Thesis; However, it makes inter-firm comparisons, using labour productivity measures, very unreliable. It also magnifies the problems of obtaining reliable data.

Marginal labour productivity is more useful in managerial terms in that it identifies the increase in output stemming from an increase in one unit of labour. It is obtained by taking the partial derivative of the production function (see Paragraph 2.2.3 below) with respect to labour.

$$\text{Marginal labour productivity} = \frac{\partial\theta}{\partial L} \tag{2.2}$$

2.2.2: Capital productivity

Capital productivity is usually defined in terms of a percentage return on capital invested. This may either use a traditional method such as the 'average rate of return' method or a discounted cash flow approach such as the 'internal rate of return' (Hawkins & Pearce, 1971). Ostensibly, capital productivity represents a more useful criterion for judging comparative performance in a market economy. Thus, a good return on capital invested is considered to far more relevant for most firms than high output per operative.

$$\text{Average capital productivity} = \pi / \kappa \qquad (2.3)$$

where π = profit
κ = capital invested

$$\text{Marginal capital productivity} = \frac{\partial \pi}{\partial \kappa} \qquad (2.4)$$

Clearly the major problem for the above is with the calculation of the 'capital invested', usually taken as the value of the fixed capital stock used in the productive process. It poses both theoretical and practical problems. The former relates to a fundamental critique of the neo-Classical assumptions of production and is covered in detail in Chapter 3.

The practical problems are principally concerned with issues of the valuation of capital assets. There are several different approaches to the valuation of fixed capital. Buildings, for example, can be valued by comparison with similar properties (dwellings), by earning potential (offices), or 'at cost' (public buildings). Similar rules apply to manufactured assets. Many valuations are essentially subjective. Different views on the real value of a company's assets will be taken by the management as opposed to the shareholders, leaving aside that view taken by a banker seeking collateral, or even a potential asset stripper.

The valuation of capital assets is often a product of the expected future stream of earnings discounted to present value. This is useless for capital productivity measurement, since both the numerator and the denominator of the productivity ratio will relate to profitability. This will give a productivity ratio of unity.

The most common approach to valuation of fixed capital is the 'perpetual inventory' approach that, essentially, attempts to value capital 'at cost' with adjustments for both fluctuating prices and depreciation. Chapter No 3 outlines this method with criticisms.

Capital productivity will be best calculated at current price levels; thus no index numbers are required to adjust the value of the profit (π). However indices will probably be needed to update the valuation of the capital stock (κ). Despite the above, much of the information is unlikely to be available (Rendall & Wolf, 1983) and therefore capital productivity is not very widely used. Problems associated with the use of official statistics will be discussed in Chapter 7.

In the particular case of contracting, most fixed capital — in particular plant — is hired. Since construction takes place on a site provided by the client (no factory needed), it is likely that very little fixed capital will be required for the productive process ¶. In any event, construction generally is not a capital intensive industry with working capital assuming more importance than fixed capital (Hillebrandt, 1984).

Clearly this will pose major problems in the use of capital productivity. The low capital requirements for contracting will result in very high figures for capital productivity. A good deal of the capital invested by construction companies tends to be in non-contracting activities such as plant hire, land and property.

This makes the capital productivity rating for individual firms more representative of their efficiency in these non-contracting activities, *e.g.* land purchases, property speculation and plant hire (Lowe, 1987b).

For the macro measures, certain of these problems do not apply when the aggregate results are computed. The problem of plant hire remains since, in the U.K. for example, plant hire without operatives is classified against the leasing section of banking and finance instead of against construction (CSO, 1979).

¶ Construction is by far the least capital intensive of all the major industries, and for some contractors who operate with a positive cash flow profile, the total (fixed plus working) capital requirements could even be negative!

2.2.3: The production function

To refine the definition of neo-Classical marginal productivity, some consideration of the production function is necessary. The Cobb-Douglas form of the production function is used here:

$$\theta = A\,L^{\alpha}\kappa^{\beta} \qquad (2.5)$$

where A = constant of efficiency
α = distributional parameter for labour
β = distributional parameter for capital

Distributional parameters are defined thus:

$$\alpha = w\,L\,/\,\theta \qquad (2.6)$$

$$\beta = i\;\kappa\,/\,\theta \qquad (2.7)$$

where w = wage level
i = return on capital invested

From the above, on the assumption of perfect competition:

$$\frac{\partial L}{\partial \theta} = \alpha\,A L^{\alpha-1}\kappa^{\beta}$$

$$= w\,(L/\theta)\,A\,L^{\alpha-1}\kappa^{\beta} = w \qquad (2.8)$$

$$\frac{\partial \kappa}{\partial \theta} = \beta\,A\,L^{\alpha}\kappa^{\beta-1}$$

$$= i\;(\kappa/\theta)\,A\,L^{\alpha}\kappa^{\beta-1} = i \qquad (2.9)$$

This confirms the (neo-Classical) marginal productivity theorem. It says that each input will receive the value of its marginal product and that the output would be just exhausted This requires the application of Euler's theorem of distribution (Henderson & Quandt, 1958)

$$\theta = wL + i\kappa \qquad (2.10)$$

Therefore:

$$w = \alpha\,\theta / L \qquad (2.11)$$

$$i = \beta\,\theta / \kappa \qquad (2.12)$$

$$\beta = (1 - \alpha) \qquad (2.13)$$

This corresponds to the neo-classical theory of distribution in which each of the two factors each receives its marginal product and the value added is divided between labour and capital in the ratio: $\alpha : (1 - \alpha)$ ¶. This gives us a revised formulation of the production function:

$$\theta = A\,L^{\alpha}\kappa^{(1-\alpha)} \qquad (2.14)$$

The above result was confirmed by several empirical studies suggesting that $\alpha + \beta \cong 1$, and that $\alpha \cong 0.65$ and $\beta \cong 0.35$ (Heathfield, 1971). While, arguably, the above may not apply to construction, it is a reasonable working assumption that $\alpha + \beta$ is approximately equal to unity.

Given the assumptions of perfect competition, average costs are equal to marginal costs; it should be possible to derive marginal productivity rates from average productivity data.

Since marginal labour productivity is assumed to be equal to the wage rate:

$$\frac{L}{\theta} = w = \alpha\,\theta / L \qquad (2.15)$$

If α is taken as a constant, then average labour productivity should provide a useful proxy for marginal labour productivity.

¶ Euler's theorem states that the following condition will be satisfied by a homogenous function:

$$x_1 f_1 + x_2 f_2 = k\,f(x_1, x_2) \qquad (2.10a)$$

Similarly for capital productivity:

$$\frac{\partial \kappa}{\partial \theta} \quad = \quad i \quad = \quad (1 - \alpha)\, \theta \,/\, \kappa \quad = \quad \pi \,/\kappa \qquad (2.16)$$

Thus, the return on capital invested is taken as equivalent to marginal capital productivity, if perfect competition can be assumed.

2.3: MULTI-FACTOR PRODUCTIVITY

2.3.1: Outline

The idea behind total-factor (or, more precisely, multi-factor) productivity measures is to overcome the limitations of the single factor approaches by taking account of all significant primary inputs. Thus, to achieve high productivity, the factors must be put together in the correct combinations. No form of single-factor productivity can deal with this as suggested by Walter Salter (1966):

> *We cannot divorce changes in the productivity of one factor from the productivity of other factors, or indeed, from all the elements within an interrelated economic system.*

The obvious problem with such a multi-factor model is concerned with the aggregation of labour and capital. The Marxist notion of treating capital as 'crystallized labour' and reducing all factors to the labour time embedded within them might provide a solution. The method outlined weights the changes in output and inputs to give a multi-factor cost index of production over time.

2.3.2: Multi-factor production function

The production function can be represented thus (Weber & Lippiatt, 1983):

$$\theta \quad = \quad f\,(\chi_1, \chi_2, \chi_3, \ldots \chi_j, \ldots \chi_n; \, t) \qquad (2.17)$$

where χ_j = input j
t = time

To obtain the rate of change of productivity with respect to time, the logarithm of the above function is differentiated with respect to time:

$$\frac{d\ \{\ln \theta\}}{dt} = \frac{d\ \{\ln f(\chi_1, \chi_2, \chi_3, \ldots \chi_j, \ldots \chi_n; t)\}}{dt}$$

$$= \frac{\partial\ \{\ln f\}}{\partial t} - \sum_{j=1}^{N} \frac{\partial\ \{\ln f\}}{\partial\ \{\ln \chi_j\}} \times \frac{\partial \{\ln \chi_j\}}{\partial t} \qquad (2.18)$$

2.3.3: Multi-factor cost function

A cost function, associated with the above production function, can be derived using McFadden's duality theorem (Weber & Lippiatt, 1983):

$$\zeta = g\ (y_1, y_2, y_3, \ldots y_j, \ldots y_n; t) \qquad (2.19)$$

$$\zeta = \sum_{j=1}^{N} y_j \chi_j \qquad (2.20)$$

where ζ = Cost function

y_j = Cost of input j

Weber and Lippiatt (1983) go on to prove that if the logarithm of the above cost function is differentiated with respect to the logarithm of a particular factor price it will give the cost share of the factor:

$$\frac{d\ \{\ln g\}}{d\ \{\ln y\}} = y_j \chi_j / \zeta = s_j \qquad (2.21)$$

where s_j = cost-share of input j

Thus for a two-factor production system, the following production and cost functions can be assumed:

$$\theta = f(L, \kappa; t) \tag{2.22}$$

$$\zeta = g(w, i; t) \tag{2.23}$$

If ζ is assumed to be equal to θ, from equation (2.20) above:

$$\frac{\partial\{\ln f\}}{\partial\{\ln w\}} = wL/\theta = \alpha \tag{2.24}$$

$$\frac{\partial\{\ln g\}}{\partial\{\ln i\}} = i\kappa/\theta = (1 - \alpha) \tag{2.25}$$

2.3.4: Multi-factor productivity measurement

Weber & Lippiatt then argue that the continuous partial derivative d {ln g }/ d {ln y } can be approximated using discrete data by the ratio of the percentage change in the total cost to the percentage change in the cost of the input j.

$$\Delta\zeta / \Delta w = (\zeta_t - \zeta_{t-1}) / (w_t - w_{t-1}) = \frac{\partial\{\ln g\}}{\partial\{\ln w\}} \tag{2.26}$$

$$\Delta\zeta / \Delta i = (\zeta_t - \zeta_{t-1}) / (i_t - i_{t-1}) = \frac{\partial\{\ln g\}}{\partial\{\ln i\}} \tag{2.27}$$

The rate of growth in multi-factor productivity is approximated by Caves *et al* (1980) thus:

$$\Delta TFP_t = \ln\theta_t - \ln\theta_{t-1} - \sum_{j=1}^{N}(\ln\chi_{jt} - \ln\chi_{jt-1})(s_{jt} - s_{jt-1})/2 \tag{2.28}$$

where ΔTFP_t = multi-factor productivity change for year t

If the above is applied to the two sector model and operating on the assumption that α is a constant, the multi-factor productivity index can be taken thus:

$$\Delta TFP_t = \ln(\theta_t/\theta_{t-1}) - \alpha\ln(L_t/L_{t-1}) - (1-\alpha)\ln(\kappa_t/\kappa_{t-1}) \tag{2.29}$$

To produce the growth rate in index number form for year t, the exponential of the ΔTFP_t measure should be multiplied by the index number for year t-1:

$$TFP_t = \exp(\Delta TFP_t)\,(TFP_{t-1}) \qquad (2.30)$$

where TFP_t = Multi-factor productivity index for year t

In this form, the calculation of a total factor productivity index presents no major computational problems and ostensibly no requirements for data beyond that used by labour and capital productivity. Unfortunately it shares, with labour productivity, the requirements for an accurate cost index and with capital productivity the need for a valuation of the capital 'stock'. It also presents problems in terms of the comprehension of the results and in limitations in use.

Of the four objectives outlined in Chapter 1, the approach is only really suitable for time-series comparisons. It is conceivable that intra-industry, inter-industry and international comparisons could use this approach. This involves a variable *t* becoming, say, technology instead of time. It would be unlikely to give reliable results unless the industrial structures of the two groups being compared were similar.

2.4: EVALUATION

Clearly neither of the main single-factor measures outlined above can provide a totally satisfactory solution to the problem. From the viewpoint of *productive efficiency*, productivity growth should be viewed as a means to an end and not as an end in itself. Assuming that the objective is minimizing the unit costs of production — productive efficiency — then there is no particular reason why improvements in single-factor productivity achieved through factor substitution should reduce overall unit costs. If, however, the aim was dealing with shortages of a particular factor — corresponding to *allocative efficiency* — then productivity growth *via* factor substitution could well become an end in itself.

For an example of the above situation, see the case of the U.K. in the 1950s and early 1960s. Labour shortages were perceived as a real constraint on economic growth and improvement in labour productivity was a specific aim in its own right (Lowe, 1987b).

2.4.1: Productive efficiency

If average labour productivity has any relevance as a measure it must be as a proxy for operational efficiency. This would only be valid with similar industrial structures for the sectors being compared. Thus, if the objective was to compare UK construction with UK steel, the very different capital-output ratios and the differing production processes used, show that average labour productivity is a dubious method. If, on the other hand, it involved comparing UK construction with US construction, which are likely to employ a similar industrial structure, the method has some merit. It, however, will suffer from the disadvantage of having to cope with a different pricing structure within the economy and fluctuating currency exchange rates. In the 1980s, the exchange rate of US dollars to the pound sterling varied from just over $1 to just short of $2.

For time-series comparisons, using labour productivity, the problem of indexation arises. In addition, labour productivity suffers from an inability to deal with technological change and factor substitution over time.

Capital productivity has certain advantages over labour productivity. The principal point is that since it is a 'pure' financial ratio, it does not suffer from the exchange rate problem and is less affected by inflation. While it suffers from the same problems as labour productivity regarding dealing with factor substitution and technical change, it is more firmly rooted in reality. Thus inefficient use of labour and materials (not to mention plant!) will be reflected in the profit margins and therefore in capital productivity.

Capital productivity as a measure is less dependent upon the assumptions of perfect competition than labour productivity. Thus inefficient use of plant and materials will push up costs and therefore labour productivity, unless checked by the impact of competition (Lowe, 1986b).

Finally, multi-factor productivity alone can deal with factor substitution. In fundamental terms, however, multi-factor productivity should be seen as a compromise between labour productivity and capital productivity weighted in the ratio α: $(1 - \alpha)$ and combines certain weaknesses of both. It also has the problem of limitation of use to time-series analysis.

2.4.2: Allocative efficiency

Labour productivity only has a role of consequence to allocative efficiency if labour in general, or some particular skill was scarce. Even then, if perfect competition was assumed, then shortages ought to imply high wages and therefore have an impact on productive efficiency. Thus, in any market near to perfect competition, productive efficiency ought to imply allocative efficiency. In the case of market imperfections leading to welfare loss this may not apply and some government intervention may be called for to correct this imbalance.

This could arise because of a taxation policy that distorted the economy *via* discriminatory indirect taxation and/or subsidies.

An instance of this occurred with the introduction, by the Wilson administration in the UK in the mid-1960s, of Selective Employment Tax (SET). This was intended ostensibly to overcome a problem that Kaldor (1966) termed 'premature maturity' ¶. This measure had the effect of taxing the service sector *via* an employment tax

¶ 'premature maturity' was characterized by the headlong rush of the economy towards the service sector with adverse consequences for manufacturing. In particular the export industries were supposedly suffering from labour shortages and the balance of trade apparently suffered as a result..

with a corresponding subsidy to employment in the production industries. It aimed to raise productivity in both sectors (Stewart, 1978), presumably by dealing with labour shortages in manufacturing and overmanning in services. It could also be argued that SET was redressing the misallocation of resources stemming from the taxation of manufactured goods *via* purchase tax and excise duty, while not taxing services. SET, itself, proved an abject failure, leaving with other things a 'time bomb' for construction in the form of labour-only subcontracting. It was soon replaced by Value Added Tax (VAT), which could be seen as achieving the same effect with fewer adverse consequences.

At the time of the introduction of SET, the economy in the UK and elsewhere had been operating for nearly two decades with a situation where labour shortages were constraining economic growth. As Salter (1966) commented:

> *...the new economic problem became that of increasing the yield of available resources.*

Thus it should be no surprise that increasing labour productivity, notwithstanding costs of production, became an end in itself instead of a means to an end. This was justified at the time *via* reference to allocative efficiency.

However, the same issues did not pertain in the 1970s and 1980s, the years of which were characterized throughout most of the developed world by mass unemployment. Consequently there is little point in the advocation of increased labour productivity unless it can be justified on the grounds of cost or time saving or, alternatively, reliability. Indeed, for the general economy, all things being equal, a labour intensive productive process is positively beneficial. It would reduce the call on social security and 'dole' payments, and increase tax revenues, both of which would be likely to assist governmental economic policy (Lowe, 1987e).

There have been some recurrences of labour shortages, specifically during the economic boom of the mid to late 1980s in the UK, in particular in the South East of England. Also, the demographic profile of the skilled workforce in the UK construction industry suggests that major problems are in store, by the next century. The 'baby boom' generation who joined the industry in the 1960s will by then be moving towards retirement age. Decisive steps must be taken in the area of training and/or automation. Despite the above, increased labour productivity cannot be justified on grounds of allocative efficiency alone.

By contrast, if the current high real rates of interest across the developed world have any meaning, it would appear that capital is a more serious constraining factor on economic growth than labour. High rates of interest clearly have the effect of discouraging private sector investment. It may also be worth mentioning the ascendency of monetarist economics from the mid-1970s onwards in many western governments.

Central to monetarism is the thesis that high levels of public sector borrowing can 'crowd out' private sector investment ¶. This led in the UK to the breakdown of the long-term resource based planning of public spending in favour of short-term control based on annual cash limits. Thus, government policy constrains both public and private sector investment. This might suggest that for the case of the overall UK economy, at least in the current economic climate, capital productivity is more valid as an indicator of allocative efficiency than labour productivity.

This will also affect the industry directly in such aspects as investment in plant and equipment, vehicles and other facilities. The points raised in Section 2.2.2: above regarding the low levels of investment by most contractors should be borne in mind.

¶ See Cross (1982) for an account of the arguments regarding the 'crowding-out' thesis and the impact of public sector investment on that of the private sector.

2.5: ANALYSIS

2.5.1: Evaluation

The suitability of the conventional labour and capital productivity measures as indicators of economic performance by construction is likely to depend on the perception of its industrial structure. Also relevant is the extent to which it corresponds to the model of perfect competition. If the industry is near to perfect competition, then either labour productivity or capital productivity ought to provide a reasonable yardstick for time-series comparisons if no significant technological changes or any factor substitution has intervened. This should also hold for inter-industry, intra-industry and international comparisons if the productive process was similar in terms of capital/output ratio and level of technology.

If the industry departs too far from the perfect competition model, then labour and, to an extent, capital productivity represent little more than the labour or capital intensity of the industrial process. The Cobb-Douglas production function is based on the assumption of perfect competition, and the assumptions derived above may no longer apply.

The construction industry is clearly not perfectly competitive in all aspects. Thus, for large-scale building and civil engineering projects, the choice of company is limited. However, it is probably much nearer to the ideal than many other industries.

The U.K. construction industry exhibits many attributes of perfect competition, such as a large number of buyers and sellers, freedom of entry and exit, and the absence of technical barriers to expansion (Hillebrandt, 1976). O'Brien, (1976) argues that the widespread use of competitive tender is indicative of the competitiveness of U.K. construction.

This is a weak argument, since perfect competition depends on perfect knowledge to communicate a given 'market price' with which all firms must comply. Clearly the competitive tender system depends upon total secrecy. In any event, there is no homogeneous product in contractual work around which a 'market price' could develop.

For speculative housebuilding and commercial development, a market price, or rather a series of location dependent market prices, will emerge. The power of the major speculative builders is sufficient to undermine any assumptions of perfect competition. There are major advertising campaigns run by companies such as Barratt and Wimpey to establish brand loyalty and differentiate their product. Such campaigns would be useless if the market were perfectly competitive. It is reasonable to assume that the above companies know what they are doing.

It is likely that the UK construction industry will fit into a model of imperfect competition (Lowe, 1983); this could verge on oligopoly in some cases and be near to perfect competition in others. It is reasonable to expect that there will be some correspondence between the efficiency in the use of capital and the return on capital invested. Thus capital productivity should provide a reasonable measure of productive and allocative efficiency (Lowe, 1987b).

Labour productivity should under certain circumstances provide a fair measure of productive efficiency. It should be noted that labour-intensive modes of production are not inherently inefficient.

Multi-factor productivity would also work well in the above situations. It also has the advantage of being less sensitive to changes in technology and factor substitution. However, it is limited in scope since it is only really suitable for time-series comparisons and will not give good results in the other cases.

2.5.2: Multiple definitions

Any attempt to measure productivity is likely to be problematical, particularly in politically sensitive areas, if only because of the definition problem. A multiplicity of definitions has emerged. Many of them owed their origin and general relevance to the economic conditions of a bygone economic era, yet they are still quoted by supposedly authoritative sources in totally inappropriate circumstances.

A good example of this concerned the furious debate over local authority direct labour organizations (DLOs) in construction within the UK (Langford, 1982). It was argued by protagonists, principally the major construction trade associations along with a few tame academics that DLOs were unproductive, inefficient, and consequently wasteful of public money. See Lowe (1983, 1986b, 1987c) for detailed discussion on these points.

It was thus argued that they should therefore be closed down (and their work allocated to the contractors!). This may or may not have been true. However, the 'evidence', generally cited, used average labour productivity, on a gross output by number of employees basis. Little or no account was taken of the markedly different types of work undertaken — over 80% of DLO output being in repair and maintenance work — or in the fundamentally different employment structures. For example, there is the use of labour-only subcontractors by contractors as opposed to conventional employees, and other key issues regarding training, safety-at-work, *etc.*

2.6: CONCLUSIONS

Given the original specification in Chapter 1, of the measures outlined above only capital productivity comes anywhere meeting the requirements. That is, the measurement of construction productivity across time, space, and economic system and avoiding, wherever possible, the use of foreign currency exchange rates and index numbers.

Any efficiency measure based on labour productivity or, for that matter, based on multi-factor productivity must use index numbers to adjust current prices to constant price terms and use exchange rates for international comparisons. By contrast, capital productivity, as a pure financial ratio, can be calculated in current price terms and currency exchange rates are not required. Thus, two potential sources of error are eliminated. Unfortunately, index numbers are still required for the updating of the existing fixed capital valuation. It does, at least, assume a lower profile than for the constant price-based ratios, and any 'noise' introduced into the model is likely to be less damaging and is constantly 'depreciating' with time.

The multi-factor model could be adapted to use year t as the base instead of some fixed year, such as 1985 or 1990, to put it on a similar footing to capital productivity in terms of indexation. It remains limited in use to time-series analysis and does not fully meet the criteria. It is not suitable for international comparisons.

Capital productivity, nevertheless, suffers from several fundamental theoretical and practical weaknesses. These weaknesses apply in both general terms and specifically for construction. Chapters 3, 4, and 5, will address these problems.

CHAPTER NO 3:

CAPITAL PRODUCTIVITY

Capital is nothing but the sum total of intermediate products which came into existence at the individual stages of the roundabout course of progression.

Eugen von Böhm Bawerk

This Chapter is concerned with a critical review of capital theory and the relationship of this to capital productivity. Capitial is taken as a durable intermediate product. An approach to capital productivity is developed as the efficiency in which the flow of investment funds are converted into profits. This approach requires capital to be measured as a disaggregated vector consisting of the various types of fixed asset and working capital.

3.1: INTRODUCTION

The neo-Classical approach to the measurement of capital productivity has come in for some justifiable criticism over the years. Much of this has centred on the problems associated with the definition and measurement of the value of the capital assets. This is needed for inclusion within the production function.

One aspect of this criticism concerns the nature of capital as a heterogeneous collection of land, buildings, plant, equipment, and vehicles. These items, while tangible, in themselves as separate entities, are not amenable to aggregation *via* a monetary value into a capital stock.

The standard production function of the form: $\theta = f\ (\kappa, L)$, on which many capital productivity measures are based, is obviously suspect. It seeks to treat capital as a homogeneous commodity with a standard rate of return. Clearly, as shown by Clark (1978), the return expected from capital cannot be divorced from its expected lifespan. Thus capital assets that have a short economic life — either due to physical decay or functional/economic obsolescence — should earn a higher rate of return than those with a longer useful economic life.

3.2: FRAMEWORK OF ANALYSIS

3.2.1: Approach

Most measures of productivity are ratios of some measure of output divided by some measure of input(s). For conventional capital productivity, this involves measuring the rate of return on capital invested. More precisely, this is a ratio of profits by an estimated value of the capital stock. The objections to this approach arise due to problems of definition, identification, and valuation of the capital stock.

3.2.2: Capital productivity as a cash flow process

This thesis starts from a different approach to capital productivity involving an input-output cash flow process as illustrated in Figure 3.2.1:

Figure 3.2.1: Investment and profit flow

Here the 'inputs' will correspond to the investment flows in the present and past years while the 'outputs' will represent the stream of profits in the current and future years. In addition, since the bulk of any investment funds will stem from undistributed profits, a feedback loop may be incorporated into the model as indicated in Figure 3.2.2 below:

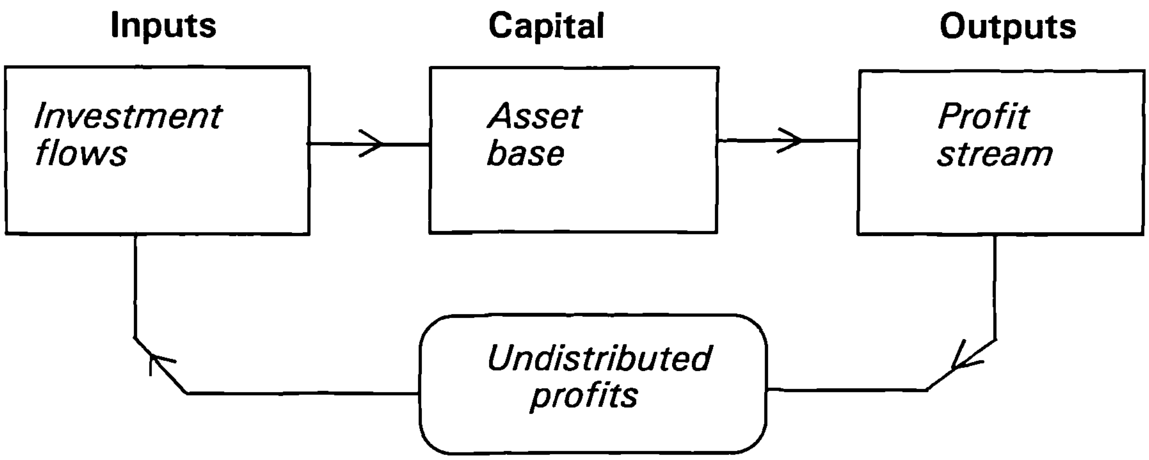


Figure 3.2.2: Investment and profit flow with feedback

The particular problem of this approach is that while both the inputs and outputs to the model are **flow** variables, the capital asset base, required for comparison, is a **stock** variable. Direct comparison between investment and profits for a given year is not possible due to the effect of time. Thus, many capital assets produce a return for several years. Equally, it is likely that both the investment profile and the profit return will be 'lumpy' particularly if the company or industry concerned is in the process of restructuring.

The return on capital will be dependent upon its anticipated working life. Short-lived assets with high depreciation will clearly require a higher return than those with greater longevity (and lower depreciation). The concept of capital must be adapted for this. This moves some way from the neo-Classical view of production stemming from the *existence* of a stock of capital assets. towards the post-Keynesian approach, where capital assets are viewed as equivalent to intermediate products (Ochoa, 1986). Thus, production stems from the *depreciation* of the capital assets ¶.

As well as fixed capital, working capital is included as an input to the model. Its depreciation is assumed to be zero and this will be reflected in the expected return. The investment required, in terms of stores, work-in-progress, *etc.*, is important for many production industries and critical for construction.

3.2.3: Capital and time

Central to this argument is the influence of time on capital. The Austrian theory works on a conception of time as a continuous dynamic process instead of a series of discrete points (O'Driscoll & Rizzo, 1985). Capital goods bear a temporal relationship with the consumption goods that they produce. Garrison (1985) argues that:

> *While the capital goods themselves are the concrete objects of valuation and exchange, the ultimate basis for their valuation and exchange is future consumption activity, which in turn, serves as the basis for production plans. Of course the continually changing demands for consumer goods imply a continual revaluation of capital goods used in their production.*

Thus, capital assets are conceived as depreciating in continuous time. This is part of the dynamic productive process in what Garrison (1985) calls *"A capital-using economy"*.

¶ Capital assets according to this framework are seen as durable intermediate goods which contribute to the productive process by their own depreciation rather than a permanent asset producing goods by virtue of their very presence. Hicks (1987) argues that capital goods as intermediate products cannot be valued as no market exists for such.

Garrison goes on to make the point that:

> *Time is the common denominator of capital goods — and the recognition of this fact is the common denominator of capital theories. But the exchanging of capital goods and the restructuring of production processes cannot be explained in terms of the alikeness of all capital. A satisfactory explanation must be in terms of the differences among capital goods — differences as perceived by the entrepreneurs who are engaged in these activities.*

Thus the implication of integrating time into the conception of capital is to express capital not as a single commodity, but as a range of different commodities differentiated in terms of lifespan. Rather than using a single element to represent capital, it should be expressed in terms of a vector of different asset types. Thus, we can take account of the true diversity of capital. See Ochoa (1986) for an account of this conception of capital.

3.2.4: Implications

The obvious way to deal with this is by expansion of the production function to the form: $\theta = f(\kappa_1, \kappa_2, \kappa_3, \ldots \kappa_n, L)$. This raises problems of distribution. It will be meaningless unless the rate of return accruing to each element of the disaggregated capital stock vector is separately identified. Such information is not recorded separately in official statistics, nor is it included in individual company accounts or other published sources.

This Chapter outlines an approach:

a) First, for the production of a disaggregated estimate of the capital stock as a vector.

b) Second, to deal with the problems associated with distribution of return between the disaggregated elements.

c) Third, to use the above to obtain figures for capital productivity for a given enterprise, sector, or industry.

3.3: A DISAGGREGATED CAPITAL STOCK VECTOR

3.3.1: Introduction

The estimation of the disaggregated capital stock vector poses several problems. There are theoretical issues of the type of model to be employed and practical concerns of data sources *etc.*

While, for example, there are estimates of the capital stock of the UK, published annually in the *Blue Book*, these are far from satisfactory for the purpose in hand. All assets are assumed to have (very long) finite life spans and are valued **gross** at current replacement costs until deemed to be scrapped (CSO, 1985). In practice most capital items will depreciate due to obsolescence – inability to compete with more modern and efficient hardware – long before they are physically worn out. A net measure of the capital stock, based on nominal resale values will be of more use for measuring capital productivity.

In any event, the *Blue Book* data are not disaggregated into different capital types except manufacturing which is split into three basic categories: land & buildings, vehicles, and plant & equipment.

3.3.2: The 'value' of the capital stock

This Section outlines a method suitable to estimate the overall capital stock that can further be disaggregated into industrial categories and types of capital. The method employed is the perpetual inventory approach. This approach uses investment data and estimated depreciation rates to assess the value of the capital stock. It is akin to the Hicksian 'backward looking' measure of capital (Hicks, 1987). There are theoretical and practical objections to this approach that will be addressed later in the Chapter.

Instead of using 'straight line' depreciation, as used in the *Blue Book*, it employs a model based on 'exponential decay'. Thus capital items are assumed to have an infinite life and to depreciate by a set percentage each year until sold for further use or for scrap. The alternative approach assigns a finite life to each capital assets over which its cost can be written-off.

The capital asset value are presented either in current prices or constant prices (*e.g.* 1985 prices) terms. The latter are essential for labour or multi-factor productivity measures. However, for the measurement of capital productivity that is a 'pure' financial ratio, it is better to use current prices for both the profit return and the capital stock. This minimizes errors stemming from the construction and maintenance of price indices.

The capital value is assessed in two parts: first, the assessment of value at the start of the period being studied with adjustments for inflation and depreciation, and second, the increase in value stemming from subsequent investment, over the period of study, again adjusted for inflation and depreciation.

The basic (current price ¶) model, with prices based in year t, is represented thus (Lowe, 1990a):

$$\kappa_t = \eta_{t-q}\kappa_{t-q}(1-\delta)^q + \sum_{y=t}^{t-q+1} \eta_y c_y (1-\delta)^{(t-y)} \qquad (3.1)$$

where

κ_t	=	capital stock in year t §
κ_{t-q}	=	capital stock at start of sequence
η_y	=	price index from year y to t
η_{t-q}	=	price index for year (t-q) to t
c_y	=	capital investment in year y
δ	=	depreciation rate

¶ The corresponding constant price model (based, say, in year 1985) would employ price indices p_y to year 1985 rather than to year t.

Strictly speaking, as a model in continuous time, the capital valuation equation and the subsequent distribution equations should be represented as integrals rather than as summations. The summation should be seen as an approximation to the true continuous models. This is of little consequence for the implementation since all the required data is presented in discrete form — annual, quarterly, monthly, *etc.*

If the heterogeneity of the capital is incorporated to allocate the capital stock into R categories, the model is amended:

$$\mathbf{k}_t = \eta_{t-q}(\mathbf{k}_{t-q} - \delta_{t-q}) + \eta[\mathbf{C} - \mathbf{D}] \qquad (3.2)$$

where $\mathbf{k}_t$ = column vector of capital stock in year t [R by 1]
δ_{t-q} = column vector of depreciation from year (t-q) to year t [Q by 1]
η_{t-q} = scalar of price index for year (t-q) to t
η = column vector of price indices from year (t-q+1) to year t [Q by 1]
$\mathbf{C}$ = matrix of capital invested from year t to year (t-q+1) of elements c_{it} [R by Q]
$\mathbf{D}$ = matrix of capital depreciation from year t to year (t-q+1) of elements δ_{it} [R by Q]

In practice, for computational reasons, the capital asset values for each of the N types of capital asset will be best calculated recursively using the base year (t-q) as the starting point thus:

$$\kappa_{it} = \eta_t \kappa_{it-1} (1 - \delta) + c_{it} \qquad (3.3)$$

where κ_{it} = capital stock category i in year t
η_t = price index from year (t-1) to year t
c_{it} = investment in category i in year t

Thus if we have an estimate for the capital stock for a base year the series can be updated each year. This involves including new investment, removing depreciated capital and adjusting for the impact of inflation by means of an appropriate price index.

In terms of data, an initial estimate of the net capital stock value is required along with information on investment following that base year. A set of capital price indices from that base year to the current year are also required. If the series starts some way back, the accuracy of the initial estimate of the stock is not likely to be critical.

Indeed, in theory, if the series of data on investment goes back far enough, we could dispense with the need for an initial estimate entirely. This assumes that most capital emanating from the base year is sold or scrapped. In practice, some capital assets, particularly buildings, have a very long lifespan. Also, there are problems in obtaining accurate (or any!) investment data from some years back (before 1948 for the UK). This makes it advisable to retain the model as originally formulated.

3.3.3: Rate of depreciation

A rate of depreciation, appropriate to the type of capital asset is assumed. This may present a problem since all subsequent calculations will depend upon the notional rate selected. While an unrealistic assumption will be immediately apparent on terms of fluctuations in the capital values, some precision will be necessary for a meaningful estimate.

One possible approach is to use the figures taken by the Inland Revenue for taxation purposes since this will probably correspond to expectations of the company management. Alternatively it may be useful to select a rate based on the average lifespan of that type of capital asset ¶.

¶ The average age of any group of capital items should bear some relationship to the average lifespan of those items. This will be discussed in Paragraph 8.3.4 below.

This can be checked empirically by use of the formula developed by Dixon (1985) as outlined in the next Section. This calculates the average age of the stock of each type of capital asset using a notional rate of depreciation. The average age thus calculated can then be checked against the results of studies into the average age of capital assets. This could follow the approach of Nevin (1964), or Prais (1986) or employ direct empirical analysis. It could also be related to estimates of the theoretical economic service life of equipment outlined by Selinger (1983).

3.3.4: Average age of capital assets

The model for estimating the average age of capital assets (Dixon, 1985) can be summarised thus:

$$\tilde{a}_{it} = [(1-\delta_i)\,\kappa_{it-1} / \kappa_{it}]\ (1 + \tilde{a}_{it-1}) \qquad (3.4)$$

where $\tilde{a}_{it}$ = average age of capital type i in year t

Assuming a steady state situation ($\tilde{a}_{it} = \tilde{a}_{it-1}$) the following can be derived:

$$\tilde{a}_i = [(1 - \delta_i)/(\nu_i + \delta_i)] \qquad (3.5)$$

where ν_i = growth of capital stock type i

$$\nu_i = [(\kappa_{it} - \eta_t\,\kappa_{it-1})/\eta_t\,\kappa_{it-1}] \qquad (3.6)$$

The average age at the start of the series in year (t-q) uses that from the 'steady state' model in equation (3.6) above. Subsequent years can be calculated using equation (3.5) of the Dixon model. Even with a substantial starting error the series will converge rapidly towards the correct age.

3.4: DISTRIBUTION

3.4.1: Expansion of the production function

To identify the distribution between N categories, some consideration of the production function is required. The simple function of the form: $\theta = f(\kappa, L)$, can be represented in Cobb-Douglas format thus:

$$\theta = A L^{\alpha} \kappa^{\beta} \tag{3.7}$$

where κ = value of capital asset

L = labour employed

α = distributional parameter for labour

β = distributional parameter for capital

A = constant of efficiency

θ = value added income

Thus α represents the share of value added accruing to labour and β the share going to capital. If the production function is expanded to the revised form:

$$\theta = f(\kappa_1, \kappa_2, \kappa_3, \ldots \kappa_n, L),$$

In Cobb-Douglas format it becomes:

$$\theta = A L^{\alpha} \kappa_1^{\beta_1} \kappa_2^{\beta_2} \kappa_3^{\beta_3} \ldots \kappa_n^{\beta_n} \tag{3.8}$$

where κ_i = value of capital asset type i

β_i = distributional parameter for asset type i

3.4.2: Apportionment of income

The first step in identifying the distribution of the income is to apportion value added between labour and capital. We can assume, from the above, that $\beta = \Sigma\beta_i$. We can make the additional assumption that Euler's Theorem (see Paragraph 2.2.3 above) applies to the above distribution problem. This will imply that all output is just exhausted and we can let $\alpha = (1-\Sigma\beta_i)$ and eliminate one variable. We may also assume that figures are available for the distribution between labour and capital. These may stem from the detailed value added figures in, for example, UK National Accounts or from company records. The problem of distribution is that of allocating profit between the various components of the capital stock vector.

3.4.3: Valuation of capital

In terms of discounted cash flow analysis, the Hicksian 'forward looking' measure (Hicks, 1987), the value of a capital asset can be represented thus:

$$\kappa_i = \sum_{w=1}^{H_i} R_{iw} / (1+\lambda)^w \qquad (3.9)$$

where
κ_i = value of capital asset i
R_{iw} = return on capital asset i in year w
λ = discount rate
H_i = life of capital asset i

This implies that:

$$R_{iw} = \beta_i \, \theta_{iw} \qquad (3.10)$$

If it is assumed that the return will decline in line with depreciation and that the capital asset will depreciate at a set rate from year two onwards, this becomes:

$$\kappa_i = \sum_{w=1}^{H_i} R_{i1} (1-\delta_i)^{w-1} / (1+\lambda)^w \tag{3.11}$$

where R_{i1} = return from capital asset i in year 1
δ_i = depreciation rate for capital asset i

As H_i becomes large, the series will rapidly converge towards:

$$\kappa_i = R_{i1} / (1 + \lambda) \{1 - [(1 - \delta_i) / (1 + \lambda)]\} \tag{3.12}$$

This can be simplified to:

$$\kappa_i = R_{i1} / (\lambda + \delta_i) \tag{3.13}$$

Since the *per capita* return on capital invested will be:

$$\rho_i = R_{i1} / \kappa_i \tag{3.14}$$

where ρ_i = *per capita* return on capital asset i

Thus by substitution and rearrangement:

$$\rho_i = (\lambda + \delta_i) \tag{3.15}$$

Thus, if the depreciation rate for a particular piece of capital is known, and an appropriate discount rate can be assumed, it is comparatively easy to calculate the expected rate of return. The discount rate is analogous to the long term net profit required after allowance for depreciation. If a zero percent discount rate was assumed, the required rate will correspond to the rate of depreciation. On the other hand, if no depreciation occurs, the required rate of return will be the same as the discount rate. The discount rate (λ) represents a more valid measure of capital productivity than the simple return on capital (ρ_i). It should be equally applicable to all types of capital asset within a given industry.

The notion of capital valuation in discounted cash flows terms is not new as shown by the following quotation from Fisher (1930):

> *Capital in the sense of capital value is simply future income discounted, in other words capitalized.*

3.4.4: Working capital

From the above definitions, working capital ought to be included within the capital vector since it requires an outlay on the part of the entrepreneur. The depreciation should be taken as zero.

3.5: THE DISCOUNT RATE

3.5.1: The overall rate of return

In practice, it is more likely that the overall rate of return will be known and the discount rate unknown. The discount rate for a given industry is identified from details of capital invested along with value added accruing to capital. From the expanded Cobb-Douglas production function, as in equation (3.8), given Euler's theorem of distribution:

$$\sum_{i=1}^{N} R_{i1} = \sum_{i=1}^{N} \phi_i \kappa_i \qquad (3.16)$$

From equation (3.14) above:

$$\sum_{i=1}^{N} R_{i1} = \sum_{i=1}^{N} (\lambda_i + \delta_i)\, \kappa_i \qquad (3.17)$$

Rearranged, this becomes:

$$\lambda = \frac{\sum_{i=1}^{N} R_{i1} - \sum_{i=1}^{N} \delta_i \kappa_i}{\sum_{i=1}^{N} \kappa_i} \qquad (3.18)$$

If the composite rate of depreciation and average return on capital invested for a particular industry j are defined thus:

$$\delta_j = \frac{\sum_{i=1}^{N} \delta_{ij} \kappa_{ij}}{\sum_{i=1}^{N} \kappa_{ij}} \qquad (3.19)$$

where δ_j = composite depreciation rate for industry j

$$\rho_j = \frac{\sum_{i=1}^{N} \rho_{ij} \kappa_{ij}}{\sum_{i=1}^{N} \kappa_{ij}} \qquad (3.20)$$

where ρ_j = overall return on capital invested in industry j

Hence from equation (3.18) above:

$$\lambda_j = (\rho_j - \delta_j) \qquad (3.21)$$

Thus the discount rate is found by taking the simple overall return on capital invested and deducting the composite depreciation rate from it.

3.6: EVALUATION

3.6.1: Outline of model

The discount rate (λ) arises out of the comparison, in Hicksian terms, of the alternative 'forward looking' (capital by value) and 'backward looking' (capital by volume) measures. This ought to be a valid indicator of changes in productivity for a specific industry over time, if the capital-output ratio remains stable. It is less valid for international or inter-industrial comparisons where the industries concerned are structurally different.

In certain circumstances, such as where a significant change in the labour intensity of the productive process occurs, an index based on some type of multi-factor productivity measure could be preferable. While the methodology is valid for this approach it is, however, it does not meet the objectives of this Thesis.

3.6.2: Potential difficulties with the model

The main criticism that can be levelled at this model is that it is based on an estimated capital stock derived using the perpetual inventory approach. The specific method of valuation is held to be suspect, particularly for the identification of movements in productivity. It is also argued that the notion of a capital stock verges on the metaphysical and is therefore too nebulous to define, let alone to measure and value.

Hicks (1987) is sceptical of such an approach, in that capital invested in the past will have a disproportionate impact:

> *Something is left, to form part of the inheritance from the past enjoyed by (say) modern England, from the roads left by the Romans, and from the clearing of the primitive forests ever so long ago. If this investment, small though it must have been by modern standards, is left to be accumulated over centuries at compound rates of interest, it must dominate capital at cost in a way that is clearly preposterous.*

Hicks gets around that particular problem by viewing capital at cost as a volume based index number measure. The dichotomy between the **value** of capital and the **volume** of capital is resolved in Hick's analysis by equating the two at the base date, with everything which happened before that date 'written off'. Thus:

> *We simply have to accept the convention that at the base date value and volume are the same. Then as we go forward from the base date we find the value changes one way, volume in another.*

The approach outlined in this Chapter is different in that base date is always taken as the current time. The surviving capital from previous periods is valued at cost, indexed to current prices, and net of depreciation instead being compounded as with the example from Hicks (1987) above.

3.6.3: Criticism of perpetual inventory

A most powerful critique of the perpetual inventory approach was outlined by Miller (1983). The thrust of the argument is that the depreciation rate is assumed to be independent of the rate of investment. Thus if, for example, a technical innovation results in a fair proportion of the existing capital assets becoming outmoded it will result in additional investment and accelerated depreciation. Here the perpetual inventory approach will pick up the extra investment but will miss the additional depreciation. We may, because of this, estimate an *increase* in the capital stock instead of the true *reduction* in the above case. This could have disastrous implications for the measurement of productivity; technical innovation could be shown to reduce productivity instead of raising it.

3.6.4: The concept of capital

On the general question of definition of capital, this is partially dealt with by the disaggregation of the stock into a vector of N different types of capital asset. If the disaggregation, is carried to its logical conclusion, each element in the stock vector would represent a single capital asset type. It is thus both tangible and real. However, it can still be argued that once each element in the vector is converted from physical units to cash value it becomes meaningless.

This does not deal with the fundamental neo-Austrian objection that there is no such thing as a capital stock or indeed that there is no such thing as a stock of a given *type* of capital asset. Thus, disaggregation will not eliminate the conceptual problems associated with the capital *stock*, however it certainly helps with the computational problems.

3.6.5: The cumulative impact of investment

Both of the above criticisms have some validity if the *capital stock* being valued refers to the miscellaneous collection of real estate, equipment and machinery used in the productive process. In this paper however, the capital stock represents the cumulative notional present value of the past stream of investments.

Any measure of productivity should be some sort of ratio of output to input(s). Here, the output is the profit – based on the share of value added going to capital – while the input is the accrued nominal value of capital investment.

Thus instead of attempting to value a diverse collection of land, buildings, plant, equipment and vehicles, this approach aims to identify the nominal present value of past investment decisions. Reasonable assumptions regarding depreciation and inflation will be used. Not only is this less susceptible to the types of criticism outlined above, but it can be argued that productivity ratios, based on such assumptions, are also more valid. They are firmly based on past investment outlays instead of on a spurious valuation of bricks, mortar and scrap metal.

Thus, apparently poor productivity figures could stem from a failure to identify technological change and accelerated depreciation. This could, in fact, be seen as an accurate reflection of dubious decisions taken in the past to invest in soon-to-be-outmoded capital.

Thus while the actual value of capital will fall with technical change, the investment 'sunk' into the (obsolete) capital will not diminish one penny! It is the latter measure that this method is aimed at capturing.

3.6.6: Summary

The modifications to capital productivity are thus more philosophical than computational. The model as formulated is akin to traditional capital productivity based on profits net of depreciation. The idea of a disaggregated vector of capital invested is important.

This modification has gone some way to dealing with the objections to the use of capital productivity to assess productive efficiency. It has not dealt with the main practical difficulties of actually measuring capital productivity. These are covered in the next Chapter.

CHAPTER NO 4:

INPUT-OUTPUT PRODUCTIVITY MEASUREMENT

Accused of apostasy from the round table of King Arthur to the square table of King Wassily, they are seen as having abandoned the quest for the Holy Grail in favour of a search for illumination of a radically different sort.

Francis Seton

This Chapter introduces Leontief's input-output approach as a solution to the problem of productivity measurement for an assembly industry. The conventional National Income accounting framework is introduced and is relaed to input-output accounting. The literature on the input-output linkages and multipliers is reviewed.

4.1: BACKGROUND

Conventional, single-factor and multi-factor, measures of productivity that attempt to relate 'output' (value added) to 'inputs' (primary inputs) suffer from a major weakness in construction. This stems from two phenomena – the growth of *off-site* prefabrication and plant hire.

The former suggests that much work is now being moved away from the site to the factory. This is factor substitution, with site labour being substituted by materials and components, or alternatively that much of the *on-site* labour is replaced by *off-site* labour (Lowe, 1987e).

In the UK, for example, only the *on-site* activities are classified as construction by the SIC (CSO, 1979). Therefore, the assembly tasks carried out on the site are not representative of the overall construction process. This can distort the labour productivity statistics, since the *off-site* labour is allocated to manufacturing. This p[oint will be discussed in the analysis in Chapter No 10. Another problem is that a good deal of private sector repair and maintenance work, carried out 'in house' by the works division of the company concerned, is classified to the industry associated with the prime product of each company.

Plant hire also causes problems since only plant and equipment hired with operatives is classified to construction. Others fall within 'renting of movables' under business services and leasing (CSO, 1979). This has the effect of removing much of the capital used in construction from the productivity ratio. It results in an artificial increase in capital productivity.

The solution proposed in this Chapter is to employ Wassily Leontief's (1941) input-output approach to measure productivity. Here the 'output' is taken as total output as opposed to value added while all inputs (direct and indirect) are allowed for in the 'input'.

Thus instead of examining the productivity attained by the construction **industry**, the approach concentrates on the construction **product.** The productivity of all the (direct and indirect) inputs used in making that product is calculated. The current practice of presenting economic transactions by commodity instead of by industry is useful. This will help to identify the repair and maintenance output, investment, and employment allocated to the primary activity of the firm and therefore 'lost' to construction through the classification system.

The total (direct and indirect) labour inputs will include those employed directly in the construction industry (site labour) and also those employed in industries that supply products or services to the construction process. This will include those working in the materials supply industries (Lowe, 1987a). They work in industries such as the extraction of raw materials and timber, and the manufacture of materials and components.

In addition, it would include those engaged in transport, distribution, and trade. Professional services (architecture, surveying, engineering design, *etc.*), banking, and finance are included. Furthermore there should be allowances for those providing goods and services used by the materials supply industries *etc.* Thus, the total labour requirements for the construction product can be estimated using Leontief's technique.

A similar approach could be used to estimate the total (direct and indirect) capital requirements for capital, and indeed the two could be used in tandem to estimate a multi-factor productivity index.

Thus the input-output method can be used to *synthesize* value added figures into total inputs (direct and indirect). In addition it can also be used to obtain gross output from final demand.

4.2: THE INPUT-OUTPUT FRAMEWORK

4.2.1: Outline

In essence, the input-output approach involves the representation of the economy as a series of simultaneous linear equations. This is much simpler than most economic models that frequently employ equations using powers, logarithms, exponentials, *etc.* It also rests on the assumption that the technical coefficients are stable over time. Therefore, to produce a fixed amount of output requires a set quantity of inputs; this accords with an 'engineering' view of the economy.

Clearly this is a gross simplification of economic reality, in that it ignores such factors as economies of scale, diminishing returns, factor substitution, *etc.* Nevertheless, its proponents claim empirical justification, with the coefficients proving to be remarkably stable over time in a variety of countries (Lowe, 1987f).

Input-output analysis concentrates on industrial interdependency, the extent to which one industry relies upon inputs from others and provides outputs to other industries. It is a measure of industrial interdependency and linkage. It thus, occupies a conceptual level midway between microeconomics, with its concern for individual firms and consumers, and macroeconomics that deals with the aggregates of production and demand.

The input-output approach is based on national income accounts. It may prove instructive to outline the national accounts before considering the input-output schema in any detail.

4.2.2: National income accounting

National income accounting concerns the definition and measurement of the key economic aggregates such as national income and production. It is based on three *identities*:

a) **Gross national product** represents the sum of all value added by the various industrial and commercial enterprises and other economic activities defined as 'productive'. It includes services as well as goods and products. It is valued in value added format instead of gross output to avoid the double counting of intermediate products. Those commodities that are supplied *via* a market mechanism are normally assessed at sale value. Goods and services provided collectively (defence etc.) or not sold through a market mechanism (state schools etc.) are valued at cost. Self-supplied services are either disregarded (housework and do-it-yourself) or imputed (residence in owner-occupied housing). It is presented in industrial groups, *e.g.* agriculture, energy and water supply, manufacturing, construction, transportation, distribution, communication, services, and public administration, *etc.*

b) **Gross national income** is the sum of earnings by residents within the state. It is normally assessed *via* tax returns *etc.* This includes personal income from employment, earnings from self-employment, corporate profits, surplus from public sector enterprise, rental income, and interest payments and is presented in the above categories.

c) **Gross national expenditure** represents the sum of all the 'final' expenditures on goods and services produced within the country. Final expenditures exclude intermediate products; those commodities used to produce other commodities instead of for use in their own right. This category will include and is presented in terms of consumer spending, government expenditure, fixed capital investment, stockbuilding, and the difference between exports and imports.

The above three measures constitute identities since the producers, the income earners, and consumers are the same people and cash moves around the economy in a circular flow. However, the figures are calculated in different ways, gross national product and gross national income from the income side while gross national expenditure comes from the consumption side. There are, as may be expected, minor discrepancies and these are balanced, by including the 'residual error'. This generally amounts to *circa* 1% of national income. See Figure 4.2.1 for an illustration of the national income aggregates.

The above identities are presented in several different forms. The aggregates may be given in *market prices* or at *factor cost* net of indirect taxation (VAT, excise duty, *etc.*) net of subsidies. They may be given *gross* or *net*; the latter exclude an allowance for depreciation of fixed assets. Also, net property income from abroad may be excluded to give *gross domestic product*.

The above relationships are summarized in Figure 4.2.2: below:

4.2.3: Input-output accounting

The input-output accounting framework employs a two dimensional array structure with inputs represented by columns and outputs by rows. It is akin to a form of 'double entry' accounting. It ought, theoretically, to be more reliable than traditional national income accounting since an error in a row total will have implications for the column totals and therefore is more likely to be identified.

Several countries, notably Japan and Denmark, have their national accounts based on the input-output principle. Others, including the UK and the USA, produce input-output tables (usually many years late! ¶), as an adjunct to the national accounts instead of a fundamental part of them.

¶ In the UK the delay of from the nominal year of the tables and the date of publication ranges from 4 years at best to 7 years at worse. In the USA, the delays appear to be even longer

Gross Domestic Product at Current Prices

FROM EXPENDITURE	£B	%	FROM INCOME	£B	%	BY INDUSTRY (FROM INCOME)	£B	%
Consumers expenditure	293.6	50%	Income from employment	249.8	62%	Agriculture, Forestry and Fishing	5.6	1%
Government consumption	91.8	16%	Income from self-employment	42.6	10%	Energy and Water Supply	21.9	5%
Gross fixed investment	88.8	15%	Income from rent	27.5	7%	Manufacturing	93.4	23%
Investment in stocks	4.3	1%	Company gross profits	70.2	18%	Construction	25.7	6%
Exports of goods and services	108.5	18%	Public sector gross surplus	7.3	2%	Distribution, Transportation, etc.	83.8	20%
			Imputed consumption of capital	3.4	1%	Services	186.4	45%
Total final expenditure	587.1	100%	Total domestic income	400.7	100%	Total after stock appreciation	416.8	100%
Less			**Less**			**Less**		
Import of goods and services	-125.2		Stock appreciation	-6.1		Adjustment for financial services	-22.2	
Adjustment to factor cost	-69.1							
			G.D.P. at factor cost	394.6		**G.D.P. at factor cost**	**394.6**	
			Less					
			Residual error	-1.9				
G.D.P. at factor cost	**392.8**		**G.D.P. at factor cost**	**392.8**				

Table 4.2.1: Gross Domestic Product U.K. 1988

Source: *Blue Book* (1989 Edition) after Kennedy (1986)

Gross National Expenditure Gross National Product	at market prices £469.5B	
Gross National Expenditure Gross National Product Gross National Income	at factor cost £400.4B	Indirect taxes £69.1B
Net National Expenditure Net National Product £345.6B Net National Income	Capital Depreciation £54.8B	
Gross Domestic Product at factor costs £394.8B	Adjustment £5.6B	

Figure 4.2.2: National Income Relationships — U.K. 1988

Source: *Blue Book* (1989 Edition)

The input-output model comprises four quadrants:

a) Quadrant I of the input-output model deals with intermediate production. This includes goods and services required to produce capital and consumption goods instead of final use. It is symmetrical, with both rows and columns representing industries. Each element in the matrix will represent the output from one (the row) industry to another (column) industry. The leading diagonal will give the intra-industrial flows. This is self-input from one industry to itself, for example subcontracting in the construction industry.

b) Quadrant II gives the final demand for goods and services. This corresponds to the gross national expenditure in conventional national income accounting. Each column represents a category of spending, *e.g.* consumption, government spending, investment *etc.*; while the rows represent an industry, *e.g.* agriculture, energy, construction *etc.* Exports are sometimes presented net of imports. Most commonly, exports are included but imports are placed elsewhere in the table, as a primary input, to balance.

c) Quadrant III of the model presents the value added with each industry being represented by a column (equivalent to gross national product). The rows represent the primary inputs (equivalent to gross national incomes), *e.g.* wages, profits, rents, and indirect (on spending) taxes net of subsidy. Usually, imports are treated as equivalent to primary inputs to balance the model. Also scrap and second-hand goods plus fees for government licences *etc.* are often included here as primary inputs for want of somewhere better to place them.

d) Quadrant IV represents the totals for Quadrants I and III and will be equivalent to gross national income/expenditure/product.

The gross output of an industry can be obtained by adding intermediate output and final demand across the appropriate row. It will be identical to the total input obtained by summing intermediate and primary inputs (value added) down the correct column. The summation of the gross outputs (or gross inputs) will give the gross social product. This will be larger than gross national product due to double counting; for example building material manufacture will be included twice, under manufacturing and under construction.

4.2.4: Formal presentation of input-output schema

The elements x_{ij} within Quadrant I — intermediate production — represent the flow of goods and services from industry i to industry j. The element v_{kj} within Quadrant III represent the value added by factor of production k within industry j. Finally, the elements y_{il} within Quadrant I represent the final use output by industry i and demand category l.

In formal terms the key aggregates can be presented as below in a modified form. This includes imports in the value added category; exports are included gross in the final demand section.

		Intermediate inputs						Final use					Gross Output
		1	2	3	4	5	6	C	G	I	E	Σ	
		QUADRANT I						***QUADRANT II***					
Intermediate outputs	1	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	y_{11}	y_{12}	y_{13}	y_{14}	y_1	z_1
	2	x_{21}	x_{22}	x_{23}	x_{24}	x_{25}	x_{26}	y_{21}	y_{22}	y_{23}	y_{24}	y_2	z_2
	3	x_{31}	x_{32}	x_{33}	x_{34}	x_{35}	x_{36}	y_{31}	y_{32}	y_{33}	y_{34}	y_3	z_3
	4	x_{41}	x_{42}	x_{43}	x_{44}	x_{45}	x_{46}	y_{41}	y_{42}	y_{43}	y_{44}	y_4	z_4
	5	x_{51}	x_{52}	x_{53}	x_{54}	x_{55}	x_{56}	y_{51}	y_{52}	y_{53}	y_{54}	y_5	z_5
	6	x_{61}	x_{62}	x_{63}	x_{64}	x_{65}	x_{66}	y_{61}	y_{62}	y_{63}	y_{64}	y_6	z_6
								$\Sigma y_j = y$					
		QUADRANT III											
Value added	M	v_{11}	v_{12}	v_{13}	v_{14}	v_{15}	v_{16}						
	W	v_{21}	v_{22}	v_{23}	v_{24}	v_{25}	v_{26}						
	P	v_{31}	v_{32}	v_{33}	v_{34}	v_{35}	v_{36}	***QUADRANT IV***					
	T	v_{41}	v_{42}	v_{43}	v_{44}	v_{45}	v_{46}						
	Σ	v_1	v_2	v_3	v_4	v_5	v_6	$\Sigma v_j = v$					
Gross Input		z_1	z_2	z_3	z_4	z_5	z_6	$\Sigma z_j = z$					$\Sigma z_i = z$

Figure 4.2.4: The transactions matrix

The gross output for a given industry i, can be represented thus as the sum of intermediate outputs (x_{ij}) and final demand (y_{il}):

$$z_i = \sum_{j=1}^{N} x_{ij} + \sum_{l=1}^{M} y_{il} \qquad (4.1)$$

where z_i = gross output for industry i

x_{ij} = flow from industry i to industry j

y_{il} = final demand from category l and industry i

The gross input for an industry j, can similarly be represented as the sum of intermediate inputs (x_{ij}) and value added (v_{kj}):

$$z_j \quad = \quad \sum_{i=1}^{N} x_{ij} \quad + \quad \sum_{k=1}^{P} v_{kj} \qquad (4.2)$$

where z_j = gross input for industry j

v_{kj} = value added for factor k and industry j

For each industry the gross output (z_i) and the gross input (z_j) will be definitionally the same and the summation of each will correspond to the gross social product (z):

$$z \quad = \quad \sum_{i=1}^{N} z_i \quad = \quad \sum_{j=1}^{N} z_j \qquad (4.3)$$

where z = gross social product

This can also be expressed thus:

$$z \quad = \quad \sum_{i=1}^{N} [\sum_{j=1}^{N} x_{ij} \quad + \quad \sum_{l=1}^{M} y_{il}] \qquad (4.4)$$

$$z \quad = \quad \sum_{j=1}^{N} [\sum_{i=1}^{N} x_{ij} \quad + \quad \sum_{k=1}^{P} v_{kj}] \qquad (4.5)$$

By law of distributivity, equations (4.4) and (4.5) can be rewritten thus:

$$z \quad = \quad \sum_{i=1}^{N} \sum_{j=1}^{N} x_{ij} \quad + \quad \sum_{i=1}^{N} \sum_{l=1}^{M} y_{il} \qquad (4.6)$$

$$z \quad = \quad \sum_{i=1}^{N} \sum_{j=1}^{N} x_{ij} \quad + \quad \sum_{j=1}^{N} \sum_{k=1}^{P} v_{kj} \qquad (4.7)$$

The national income identities, can be formally presented thus:

$$GNP = \sum_{j=1}^{N} \sum_{k=1}^{P} v_{kj} \tag{4.8}$$

$$GNY = \sum_{k=1}^{P} \sum_{j=1}^{N} v_{kj} \tag{4.9}$$

$$GNE = \sum_{l=1}^{M} \sum_{i=1}^{N} y_{il} \tag{4.10}$$

where: GNP = gross national product
GNY = gross national income
GNE = gross national expenditure

The first two, GNP and GNY can be shown to be equal from equations (4.8) and (4.9) by the commutivity of summation. Gross national expenditure can be shown to be identical to the first two via the laws of distributivity and commutivity of summation from equations (4.4) and (4.5).

4.3: THE LEONTIEF INVERSE

4.3.1: The demand-side Input-output model

The (direct) technical coefficients give the quantity of intermediate production required from a given industry i to another industry j, necessary to produce one unit of total input for industry j.

$$a_{ij} = x_{ij} / z_j \tag{4.11}$$

where a_{ij} = direct technical coefficients from industry i to j.

In the terms of linear algebra, the technical matrix **A** represents the [N x N] array of elements a_{ij}. The final demand array **y** represents a [1 x N] column vector of elements $\Sigma\, y_{ij}$ and the gross output array represents a [1 x N] column vector $\mathbf{z}_i$ of elements z_i. It should be noted that the gross output vector is identical to the transposition of the [N x 1] row vector $\mathbf{z}_j$ of elements z_j, the total input array. From the above it follows that:

$$\mathbf{A} = \mathbf{X}\,\hat{\mathbf{Z}}^{-1} \tag{4.12}$$

$$\mathbf{A}\,\mathbf{z}_j^T + \mathbf{y} = \mathbf{z}_i \tag{4.13}$$

where
$\hat{\mathbf{Z}}^{-1}$ = inverse of diagonal matrix of z_i [N x N]
$\mathbf{X}$ = matrix of intermediate flows [N x N]
$\mathbf{A}$ = technical matrix [N x N] (demand side)
$\mathbf{z}_i$ = gross output column vector [1 x N]
$\mathbf{z}_j^T$ = transpose of gross input row vector [N x 1]
$\mathbf{y}$ = final demand column vector [1 x N]

Rearranged this becomes:

$$\mathbf{z}_i - \mathbf{A}\,\mathbf{z}_i = \mathbf{y} \tag{4.14}$$

This can be rewritten thus:

$$[\mathbf{I} - \mathbf{A}]\,\mathbf{z}_i = \mathbf{y} \tag{4.15}$$

where $\mathbf{I}$ = identity matrix

Assuming that the matrix **[I-A]** is non-singular, and therefore invertible:

$$[\mathbf{I} - \mathbf{A}]^{-1}\,\mathbf{y} \quad = \quad \mathbf{z}_i \qquad (4.15)$$

where $[\mathbf{I} - \mathbf{A}]^{-1}$ = Leontief inverse matrix (demand-side) of elements g_{ij}. [N X N]

The inverse Leontief matrix enables the estimation of the total requirement (direct and indirect) for intermediate output. This is dependent upon the assumption of fixed technical coefficients. Thus each element g_{ij} of the demand-side Leontief inverse shows the flow of goods and services from industry i to industry j that is necessary for one unit of gross output for industry i. The element g_{ij} is the partial derivative of change in intermediate output with respect to change in gross output.

$$g_{ij} = \frac{\partial x_{ij}}{\partial z_i} \qquad (4.16)$$

where g_{ij} = flow from industry i to j per unit gross output i

Thus, the Leontief inverse matrix acts to synthesize the final demand vector into the gross output vector. It is very useful to assess the implications on other industries of a projected rise in gross output.

Alternatively the Leontief inverse can be viewed as akin to the conventional national income multiplier. The technical matrix **A**, gives the initial (direct) implications. The second round is given by $\mathbf{A}^2$; the third round by $\mathbf{A}^3$, *and so on*. The total impact will be given by the following series:

$$\text{The multiplier} = \mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \mathbf{A}^4 + \ldots + \mathbf{A}^N \qquad (4.17)$$

Rewritten this becomes:

$$\text{The multiplier} = \sum_{s=0}^{S} \mathbf{A}^s \qquad (4.18)$$

If the every element in the matrix A tends to zero as s -> infinity, as s becomes large. The multiplier will tend towards $[\mathbf{I} - \mathbf{A}]^{-1}$, the Leontief inverse, if it exists.

$$\sum_{s=0}^{S} \mathbf{A}^s \quad = \quad [\mathbf{I} - \mathbf{A}]^{-1} \qquad (4.19)$$

This will apply if all the elements of **A** are not less than zero and are less than unity $\{0 \leq a_{ij} < 1\}$. Also every column sum in the technical matrix must be less than unity $\{\Sigma a_j < 1 \text{for all i}\}$. See Casson (1973) for a proof of the Theorem given in (4.19).

4.3.2: The supply-side input-output model

This approach is similar to the above. Instead of normalizing the intermediate outputs by total inputs to create the production matrix, total outputs are used to create the allocation matrix. The model then enables the value added row vector to be synthesized into the total input row vector:

The value added array **v** represents a [N x 1] row vector of elements Σv_{kj}.

$$b_{ij} \quad = \quad x_{ij} / z_i \qquad (4.20)$$

where b_{ij} = direct allocation coefficients from industry i to j.

$$\mathbf{B} \quad = \quad \hat{\mathbf{Z}}^{-1} \mathbf{X} \qquad (4.21)$$

$$\mathbf{z}_i^T\mathbf{B} \quad + \quad \mathbf{v} \quad = \quad \mathbf{z}_j \qquad (4.22)$$

where
$\mathbf{B}$ = allocation matrix [N x N] (Supply-side)
$\mathbf{z}_i^T$ = transpose of gross output vector [1 x N]
$\mathbf{z}_j$ = gross input row vector [N x 1]
$\mathbf{v}$ = value added row vector [N x 1]

This becomes:

$$\mathbf{z}_j \quad - \quad \mathbf{z}_j \, \mathbf{B} \quad = \quad \mathbf{v} \tag{4.22}$$

$$\mathbf{z}_j [\mathbf{I} - \mathbf{B}] \quad = \quad \mathbf{v} \tag{4.23}$$

$$\mathbf{v} \, [\mathbf{I} - \mathbf{B}]^{-1} \quad = \quad \mathbf{z}_j \tag{4.24}$$

where $[\mathbf{I} - \mathbf{B}]^{-1}$ = Leontief inverse matrix (supply-side) of elements h_{ij} $[\mathrm{N} \times \mathrm{N}]$

$$h_{ij} = \frac{\partial x_{ij}}{\partial z_j} \tag{4.25}$$

where h_{ij} = flow from industry i to j per unit value added j

4.4: APPLICATIONS

4.4.1: Stability of Coefficients

The model is based on the assumption of (relatively) fixed technical coefficients. Therefore, the power of the method will largely depend upon the stability of the coefficients (g_{ij} or h_{ij}) in the Leontief inverse. As suggested by Edgeworth, (1881):

> *"To treat **variables** as **constants** is the characteristic vice of the unmathematical economist."*

The other simplifying assumptions of a linear production function, constant returns to scale, and the absence of factor substitution, can safely be ignored if the first assumption holds. This will be discussed in Paragraph 8.2.4 below.

Tests of the stability of the coefficients can be used for other purposes. For example Bon (1986) tested the comparative stability of the elements in the Leontief inverse for the demand-side against the supply-side model for the broad industrial groups in the United States. This aims to identify the relative importance of supply variables against demand variables in determining industrial output. This analysis was later extended to cover the UK economy (Bon & Xu Bing, 1993).

The assumption of fixed technical coefficients can also be used for economic forecasting. It is not used as a direct tool for but to add an additional dimension to economic forecasts, *e.g.* translating predictions of overall final demand into industry-by-industry forecasts of gross output (Lowe, 1987f).

A related issue concerns the multiplier effects of a change in a given sector of the economy. The multiplier effects can be fully evaluated in terms of direct and indirect implications. An example of this approach is the work of Beke (1982) examining the impact of construction output on the general economy.

4.4.2: Forward linkages

The Leontief inverse has several other uses, principally in the area of the understanding the underlying structure of the economy. For example, it gives a good idea of industrial interdependency by the calculation of forward and backward linkages (Bon, 1991) (Bon & Pietroforte, 1990).

Forward linkages express the 'downstream' implications of output by a particular industry. This is the multiplier effect describing the ratio of gross output to unit output by the industry in question. In other words, by how much final demand will have to increase to ensure that, say, the output of construction increases by one unit? This depends on the assumption that the technical coefficients remain fixed. Total forward linkages are calculated by summing the appropriate row in the supply-side Leontief inverse matrix:

$$\text{Direct forward linkage for industry } i = \sum_{j=1}^{N} b_{ij} \tag{4.26}$$

$$\text{Total forward linkage for industry } i = \sum_{j=1}^{N} h_{ij} \tag{4.27}$$

4.4.3: Backward linkages

Backward linkages by contrast represent the supply implications for output by a given industry, *i.e.* the sum of all purchases from all other industries in the economy including itself (Bon, 1991). Total backward linkages are calculated by summing the appropriate column in the demand-side Leontief inverse matrix.

$$\text{Direct backward linkage for industry } j = \sum_{i=1}^{N} a_{ij} \tag{4.28}$$

$$\text{Total backward linkage for industry } j = \sum_{i=1}^{N} g_{ij} \tag{4.29}$$

The latter is useful, in the identification of implications on local industry of, say, the construction of a manufacturing plant. For example, see Lowe (1986c), for a discussion of the impact of the building materials productive capacity in Tanzania. This discussed the construction of cement plants on imports. In the specific example it proved negative, because of the *absence* of backward linkages from the new plants to the local economy. Raw materials and spare parts were required to be imported to keep the plants operational, thus outweighing the benefits.

4.4.4: Input-output multipliers

A number of multipliers can be derived from the input-output framework expressed above. These are fully covered by Bon (1988) and by Miller & Blair (1985). The multipliers of most interest for this Thesis are the input and output multipliers and the ratio of direct backward to direct forward linkage indicators.

The output multiplier may be defined as the total value of production in all industries of the economy that is necessary to satisfy a unit's worth of final demand for industry j's output. This corresponds to the total backward linkage indicator in equation (4.29) above.

$$o_j = \sum_{i=1}^{N} g_{ij} \tag{4.30}$$

where o_j = total output multiplier for industry j

The higher the above output multiplier the greater the total impact on total output in the economy of a unit's worth of output following spending on that industry.

In a similar vein, the input multiplier is identical to the total forward linkages indicator expressed in equation (4.27).

$$\psi_i = \sum_{j=1}^{N} h_{ij} \tag{4.31}$$

where ψ_i = total input multiplier for industry i

The ratio of the above two multipliers is equivalent to the ratio of of direct backward to direct forward linkage indicators.

$$\varphi_i = o_j / \psi_i \tag{4.32}$$

where φ_i = output to input multiplier for industry i

4.5: INPUT-OUTPUT STUDIES OF THE CONSTRUCTION INDUSTRY

4.5.1: Output studies

The static open Leontief approach outlined above is not ideal for the case of the construction industry. The static model identifies fixed capital formation and stockbuilding as a final demand. Thus the bulk of the output of the construction industry is classified as final demand, with little remaining as intermediate output.

All new work is included as investment, while repair and maintenance work on domestic dwellings and on government buildings are categorized as consumption and government spending respectively. Only the residue, comprising the repair and maintenance on non-governmental buildings and industrial self-input from construction, is classified as intermediate output. Because of this, the forward linkages from construction are very weak.

The input multiplier for construction is low for construction for the reasons that the forward linkages from construction are weak. This is liable to be partially redressed in the future as the repair and maintenance sector becomes more important as against new bulding in the more mature developed economies (Bon, 1988). This stems from the age profile of the building stock and the slowdown in economic growth which may be expected given the stage of economic development. The growing importance of the repair and maintenance sector is being experienced not only in countries such as the UK and the USA but also dynamic 'Pacific rim' economies such as Singapore, Malaysia, and Hong Kong.

To fully appreciate the output role of the construction industry in terms of industrial investment would require the use of a 'dynamic' input-output model. This fully integrates capital investment within the structure of the model. While this is outside the immediate scope of this Thesis, it presents a potentially useful approach for extending the model.

4.5.2: Input studies

The model, as outlined, is more successful in modelling the inputs to the construction industry than for the outputs. There are very strong input-links to construction from a variety of industrial groups. This includes the extractive industries such as forestry and quarrying, the manufacturing industries, and the distribution, transportation and business services.

Bon (1988) demonstrates the strength of both the direct-backward linkages and total backward linkages from construction in the US economy. This has been extended to other countries (Bon & Pietroforte, 1990) (Bon, 1991).

The disparity between the input and output links for construction is demonstrated most graphically by the output to input multiplier. Construction shows by far the largest value for this multiplier in the USA with a ratio consistently over 1.5. Only manufacturing, of the other sectors has a value in excess of unity (Bon, 1988). This is explained by the nature of the output for these two sectors. Both manufacturing and construction are producers of capital goods (Bon 1988). This weakens the forward linkages, at least for the static input-output model, by classification of all capital goods as final demand rather than intermediate output.

4.5.3: Use of input-output analysis in productivity measurement

In this Thesis, the principal use of input-output analysis concerns the ability of the supply-side Leontief inverse matrix to 'synthesize' *direct* capital inputs and direct profits outputs into *total* inputs and outputs. This enables us to assess the productivity of the total construction process and not simply the *on-site* assembly operations. It goes some way to the elimination of the problems caused by prefabrication and the use of hired plant as outlined in Section 4.1.

The input-output tables are now prepared using the commodity-by-commodity format, instead of the traditional industry-by-industry approach. This might overcome the problem of the omission of *in-house* repair and maintenance work carried out by the works departments of non-governmental industrial concerns in the UK as discussed in Section 4.1.

Some use has been made of the input-output approach for the measurement of productivity but in the vast majority of cases this has been based on labour productivity as opposed to capital productivity. See, for example, the work of Varnas (1988) who applied the approach to the UK construction industry. Also relevant is the approach of Postner & Wesa (1983) for Canada.

Ochoa (1987) takes the measurement of labour productivity to a logical conclusion. He produced an input-output based neo-Marxist study of labour productivity in the US economy over the period 1947 to 1972. Capital is handled as a vector of embedded labour hours using Passinetti's (1973) idea of a vertically integrated economy.

CHAPTER NO 5:

INTERNATIONAL COMPARISON

OF PRICING SYSTEMS

> *... a value-concept, however satisfying on philosophical, logical, or mathematical grounds, will never command universal credibility unless it permits direct intertemporal, international, and intersystemic comparisons of greater validity than country-specific or arbitrarily chosen price systems.*
>
> Francis Seton

This Chapter introduces an approach to compare pricing systems across time and economic system. The method enables allowance to be made for discriminatory indirect taxation and subsidies so as to identify the underlying price structure. The computation of eigenprices is discussed along with their rôle in productivity measurement.

5.1: INTRODUCTION

5.1.1: Background

Any attempt to analyze the construction industry across time, international boundaries, and economic systems is liable to fail due to lack of comparability in terms of prices. This might apply to the problem of establishing a suitable price base for time-series analysis. Equally the instability of currency exchange rates for international comparisons causes difficulties, even if we leave aside the question of conversion problems affecting non-'hard' currencies of Eastern Europe and the Third World. The currency conversion problem can be sidestepped by reliance on pure financial ratios, such as the proportion of GDP absorbed by construction or return on capital invested by construction. However, there are still residual doubts about the validity of the comparison.

For example, the comparison of the proportion of gross domestic product spent on housing in the USA with that spent in the Russian Republic will be dependant upon the relative prices paid for housing in each country. Raw comparisons would have little credence without adjustment to take account of the differing underlying pricing structures within the two economies. Equally, different definitions and classifications that may be employed in the compilation of the statistics, from which the ratios are calculated.

Thus, several factors will influence the level of prices paid for a given commodity. This will include the incidence of differential rates of indirect taxation and subsidies, the degree of state intervention within the economy, and the values placed on certain activities and products by society. These problems are compounded by the fact that construction sevices are not widely traded on an international basis. This does not apply to most other industrial groups, notably manufacturing, energy, agriculture, insurance, and other financial services. Construction materials are, to some extent, traded internationally (Lowe, 19687a).

It is true that there exists a specific 'international' market for construction services. This consists, in the main, of oil-funded projects in the OPEC countries and of development-aid funded projects elsewhere in the Third World. However, leaving this market segment aside, construction remains the last bastion of the 'national' market (Whitworth & Lowe, 1988). Apart from the 'international' market the penetration of contractors into overseas markets is very limited despite the success of the Japanese firms in the USA and Australia. Equally, there are few signs to date of the development of multinational contracting firms to match the multinational conglomerates that dominate world manufacturing and energy.

Thus, we have no guarantee that the prices allotted to construction products and the factors of production and raw materials used, have any comparability between, say West Germany and Spain. Comparisons will be less valid between the UK and Hungary or, for that matter, North Korea.

For similar reasons, a long term time-series analysis of one country is likely to face similar problems of comparability especially if there have been major structural changes in the economy over the appropriate time frame.

The process set in train by the creation of the 'single European market' after 1992 is likely to ease the opening of the 'national' construction markets within the European Community. Also, the spreading influence of the Japanese and South Korean construction firms could have an impact. Thus, a comparison of the underlying price structure of the construction sector going beyond accepting market prices at face value might be illustrative. It will help to assess how well the UK based contractors will fare if, and when; their fiefdom is invaded by French, German, Japanese, or even South Korean competitors.

The hypothesis implied in the above is that construction is more likely to display variability in its underlying price structure across space and economic system than the commodities and services that are more commonly traded internationally.

Thus, the likely future 'internationalization' of construction will affect the underlying price structure. Thus, it is arguably more important to take these factors into account for construction than for international traded commodities such as oil, coal, grain and manufactured goods.

5.1.2: Methodology

The approach used in this Chapter is to establish a formal definition and measure of the underlying price structure for the construction sector of the UK economy. This approach employs the concept of 'eigenprices' as developed by Francis Seton (1985), which in turn uses the techniques of input-output analysis developed by Wassily Leontief (1941). This Chapter presents a critical summary of Seton's work.

Seton (1985) outlines three approaches to the problem of dealing with a lack of comparability of pricing structure using analogies from horticulture thus:

i) **Price-pruning** was developed by Abram Bergson (1961) to assist with the comparison of the national income of the USSR; Soviet prices were amended to form a truer reflection of the internal factor costs by 'pruning' away the non-economic elements. Thus prices distorted for political or other reasons are adjusted to make a comparison of Soviet national income more comparable to those of the western market economies.

ii) **Price-grafting** involved the use of index numbers to revalue the main economic aggregates of one country in terms of the price levels of another. It may have been possible to compare, say the UK and the USSR, by 'grafting' the price levels of the USA to both. It is likely that a different result would follow if the comparison was made by use of, say, Hungarian price levels.

iii) **Price-cloning** implies the use of *"a single concept to generate family groups of country- and time-specific price systems"* (Seton, 1985). These prices would produce universal indicators evaluated by a uniform principle that is applicable across time and economic system. An example of this type of approach can be found in the Marxian labour theory of value, where the value of a commodity is reduced to the labour content of its production. Capital is treated as a product of past inputs of labour as akin to an intermediate product.

Seton's methodology is based on this third approach. It attempts to create a framework, based on the input-output approach, able to produce both commodity and factor valuations. It is intended that Marxian as well as neo-Classical price concepts, not to mention the Sraffian approach, the production of commodities by commodities (Sraffa, 1960), can be presented as special cases.

5.2: EIGENPRICES AND THEIR DERIVATION

5.2.1: Introduction

The outline of the approach here is based on the Leontief input-output framework as introduced previously. The notation is identical with the two key distinctions.

i) First, the schema is not presented in market prices. Each row is presented in terms of physical units for [N] final use commodities and [P] primary factors of production. There are practical difficulties of the use of physical units and substitutes surrogate 'currency' as various types of goods *lira* (coal *lira*, power *lira, etc.*) and factor *lira* (labour *lira*, capital *lira*, *etc.*). This has the advantage that, if necessary, it will enable us to assume the existence of a single notional currency – the *lira* – and thus add rows together. Consequentially, the columns are not summed to obtain the total input row vector ($\mathbf{z}_j$). Instead it is taken as the transpose of the total output column vector ($\mathbf{z}_i$).

ii) Secondly that indirect taxes less subsidies are not considered as part of the main 'value added' in Quadrant III, but are instead treated separately. A new 'residual surplus' row vector τ, associated with, although not necessarily identically equal to, the indirect taxes (net of subsidies) is introduced to balance the model. This operation clearly requires the summation of rows and therefore the assumption of a single surrogate currency for this purpose.

The above treatment of indirect taxes as a type of surplus or 'profit' on top of the factor costs for the economic system implies that a uniform 'markup' should be applied to the factor costs to balance them with final demand and thus preserve the national income accounting identities:

$$\sigma = 1/\phi - 1 \qquad (5.1)$$

where σ = uniform 'markup' rate
ϕ = uniform cost/turnover ratio

The markup rate is a ratio of the total 'surplus' by the revised value added total:

$$\sigma = \frac{\sum_{j=1}^{N} \tau_j}{\sum_{k=1}^{P} \sum_{j=1}^{N} v_{kj}} \qquad (5.2)$$

where τ_j = indirect taxes *less* subsidies for industry j
τ = row vector of indirect taxes *less* subsidies

Therefore, equation (4.2) will be replaced thus:

$$z_j = \sum_{i=1}^{N} x_{ij} + \sum_{k=1}^{P} v_{kj} + \tau_j \qquad (5.3)$$

In addition there will be consequential trivial changes to equations (4.5), (4.7), (4.8) and (4.9). Apart from the above, the schema outlined in Chapter 4 should suffice for the revised model bearing in mind that summation of rows at this stage is only used for the computation of the row vector τ.

5.2.2: Cost fetishism

There have been many attempts to express the output of an economic system in terms of a single factor input. The most notable of these is the Marxian concept of the labour theory of value. However, there is no reason why any other factor should not be used, for example oil, coal, or any other store of energy could be similarly employed.

In the factor *monomania* approach, outlined by Seton (1985), one factor of production is accepted as a cost to the economy. All other inputs would be valued only in terms of the amount of that factor that they absorb. For the labour theory of value, capital and land are deemed to have value only in terms of *crystallized* labour. This is assumed to have been absorbed, over the years, in the production of the capital goods and the preparation of the economically useful land.

A similar approach could be taken for any primary input into the economic system. Thus a 'capital theory of value' ¶ could produce a model where all products were valued according to their total (direct and indirect) use of capital. Equally, there is much to be said for valuing goods in terms of energy usage instead of monetary valuation.

¶ Alec Nove quotes Tugan-Baranovsky's observation that if horses could write economics, we might have been taught a "Horsepower theory of value". (Seton, 1985)

Such an approach fits in with the philosophy underlying the various 'single-factor' productivity measures outlined in Chapter 2, where the efficiency of the productive process was assessed in terms of the use of a single factor of production.

The factor input coefficients may be calculated from the matrix of primary input factors by normalizing each element of value added by the total input thus:

$$q_{kj} \quad = \quad v_{kj} / z_j \tag{5.4}$$

where q_{kj} = primary input factor

In terms of matrix notation:

$$\mathbf{Q} \quad = \quad \mathbf{V}\,\hat{\mathbf{z}}^{-1} \tag{5.5}$$

where: **Q** = matrix of primary-input factors of elements q_{kj} [P X N]

V = matrix of factor inputs (value added) of elements v_{kj} [P X N]

To synthesize the direct factor costs into total (direct and indirect) factor costs, entails the use of the Leontief inverse:

$$\mathbf{L} \quad = \quad \mathbf{Q}\,[\mathbf{I} - \mathbf{A}]^{-1} \tag{5.6}$$

where: **L** = cost matrix of full (direct and indirect) costs for N products expressed in terms of P different factors of elements l_{kj} [P X N]

The above approach can give a range of commodity costings, one for each factor of production ¶. However they are of little use when making decisions regarding

¶ At this stage each row of the tableau, representing industries and primary inputs is treated separately and is counted in physical units or, at least, in separate factor and industry currencies.

choice between factors. This arises because they will be valued in different units (labour hours, capital units, *etc.*). Thus some form of *weighting* of the various factors, presumably reflecting their relative scarcity or utility, will be necessary to obtain a single costing for all primary factors. No rational basis for weighting the factors priced in labour *lira* and capital *lira* into 'convertible currency' has so far emerged from the analysis, unless determined in advance based on ideology.

5.2.3: Use fetishism

It requires a greater conceptual leap to value commodities by their use as opposed to their costs. A *monomaniac* scheme would imply that a single final output would be deemed to be uniquely beneficial to the final users. All other products and factors would be judged in terms of their contribution to the production of that single good. If, for example, construction was accepted as the sole worthwhile good produced by an economy, then each component of the economy would be valued in terms of its contribution to the final use output of construction products.

To represent this concept in formal terms, first the factor quota matrix **R** should be calculated:

$$r_{kj} = v_{kj} / v_k \qquad (5.7)$$

where r_{kj} = proportion of value added for *jth* industry absorbed by the *kth* factor of production

v_k = value added for *kth* factor of production

The above can be expressed in matrix notation thus:

$$\mathbf{R} = \mathbf{V}^{-1}\ \hat{\mathbf{V}} \qquad (5.8)$$

where: $\hat{\mathbf{V}}^{-1}$ = diagonal inverse matrix of factor value added totals with elements v_k on leading diagonal [P x P]

R = matrix of factor quota of elements r_{kj} [P x N]

The final use quota matrix $\hat{\mathbf{M}}$ is an [N X N] diagonal matrix with the proportion of final use against total output on the leading diagonal.

$$\hat{\mathbf{M}} \quad = \quad \hat{\mathbf{Y}}\,\hat{\mathbf{Z}}^{-1} \qquad (5.9)$$

where: $\hat{\mathbf{Y}}$ = diagonal matrix of final use totals with elements y_j on leading diagonal [N X N]

$\hat{\mathbf{M}}$ = diagonal matrix of final use as proportion of total output on leading diagonal [N X N]

The factor norm matrix can now be calculated by pre-multiplying the transpose of the factor quota matrix by the transpose of the supply-side Leontief inverse itself pre-multiplied by the diagonal matrix of final use quotas.

$$\mathbf{N} \quad = \quad \hat{\mathbf{M}}\,[\mathbf{I} - \mathbf{B}]^{-1T}\,\mathbf{R}^{T} \qquad (5.10)$$

where: $\mathbf{N}$ = factor norm matrix of elements n_{ik} [N X P]

$[\mathbf{I} - \mathbf{B}]^{-1T}$ = transpose of supply-side Leontief inverse of elements h_{ij} [N X N]

$\mathbf{R}^{T}$ = transpose of factor quota matrix [N X P]

As in the case of the matrix **L**, some form of prior valuation or *weighting* is required to transform the product *lira* into a unified currency. Thus, the establishment of a rational basis for valuation is necessary for progress to be made.

5.2.4: Some observations on matrix similarity

It should be noted that from the definitions the following identities can be established since **A** and **B**, and also $[\mathbf{I} - \mathbf{A}]^{-1}$ and $[\mathbf{I} - \mathbf{B}]^{-1}$ are similar matrices:

$$\mathbf{B} \quad = \quad \hat{\mathbf{Z}}^{-1}\,\mathbf{A}\,\hat{\mathbf{Z}} \qquad (5.11)$$

$$[\mathbf{I} - \mathbf{B}]^{-1} \quad = \quad \hat{\mathbf{Z}}^{-1}[\mathbf{I} - \mathbf{A}]^{-1}\hat{\mathbf{Z}} \qquad (5.12)$$

It can be similarly be established that:

$$\mathbf{R} \quad = \quad \hat{\mathbf{V}}^{-1}\mathbf{Q}\ \hat{\mathbf{Z}} \qquad (5.13)$$

From the above and from equation (5.10) it can be shown that:

$$\mathbf{N} \quad = \quad \hat{\mathbf{Y}}^{-1}\mathbf{C}^{T}\ \hat{\mathbf{V}}^{-1} \qquad (5.14)$$

5.2.5: Eigenprices

Thus, we now have a [P X N] matrix **L** — the cost matrix — representing the costing of [N] products in terms of [P] different factors of production. We also have an [N X P] matrix **N** — the factor norms — representing the extent to which each of the P factors contributes to each of the N final use products.

Weighting of the cost matrix **L** can be accomplished by its pre-multiplication by a [1 X P] row vector **f** of elements (f_1, f_2, f_3, *etc.*). Similarly the weighting of the factor norm matrix **N** can be given by its pre-multiplication by a [1 X N] row vector **p** of elements (p_1, p_2, p_3, *etc.*).

The factor *monomaniac* approach based on factor k, as, say, for the labour theory of value, can be represented by a factor weighting vector $\mathbf{i}_k$. This corresponds to the k*th* row of the identity matrix, for example (0, 0, ... , 1, ... , 0), or alternatively as a zero vector with a one as the k*th* element. Thus for the labour theory of value, the k*th* row would correspond to labour and consequentially the cost of all other factors would be disregarded.

Similarly, the use *monomaniac* approach, based on final use i, will be obtained by using the weighting vector $\mathbf{i}_i$, the i*th* row of the identity matrix, as for example (0, 0, ..., 1, ..., 0), the zero vector with a one as the i*th* element.

Other weightings present more problems and to achieve this, it remains necessary to attempt to unite the two principles of valuation by cost and by use implied in the two approaches. Seton (1985) likens this to the synthesis implicit within neo-Classical 'supply and demand' economics of that most uncomfortable dichotomy between 'value-in-exchange' (cost-based) and 'value-in-use' (utility-based). The Marxist economists and their ilk have to deal with this dichotomy.

To remind us of the formal definitions of the two processes:

$$1/\phi \; \mathbf{f} \; \mathbf{C} \quad = \quad \mathbf{p}\,(\,\mathbf{f}\,) \tag{5.15}$$

$$\mathbf{p} \;\; \mathbf{N} \quad = \quad \mathbf{n}\,(\,\mathbf{p}\,) \tag{5.16}$$

where
p (f) = row vector of total (uniformly marked up) costs when factors are valued at **f** [1 X P]
n (p) = row vector of factor-norms when final use products are valued at **p** [1 X N]
f = row vector of factor weightings [1 X N]
p = row vector of final use weightings [1 X N]

The definition of matrix **L** suggests that it represents a transformation or 'mapping' from the factor prices to a correlative set of commodity prices. By analogy, the definition of matrix **N** suggests a 'mapping' from commodity prices back to factor prices. Seton (1985) contends that it may be instructive to see how a given set of factor weighting would 'map back' to factor-price space when subjected to the two transformations consecutively.

To enable progress to be made, two new matrices are defined. The first is the cost-norm matrix **F**, the conspectus of the factor-norms of all single-yield bases weighted in proportion to the single-factor costs of the base-yield commodities. The second is the norm-cost matrix **P**, the conspectus of norm-weighted costs:

$$\mathbf{F} \quad = \quad \mathbf{L\,N} \tag{5.17}$$

$$\mathbf{P} \quad = \quad \mathbf{N\,L} \tag{5.18}$$

where $\mathbf{F}$ = cost-norm matrix of elements f_{kh} [P x P]
$\mathbf{P}$ = norm-cost matrix of elements p_{ij} [N x N]

The 'map back' process can be formally noted thus:

$$\mathbf{n}\,[\,\mathbf{p}\,(\,\mathbf{f}\,)\,] \quad = \quad \mathbf{n}\,(1/\phi\ \mathbf{f}\ \mathbf{L}\,) \quad = \quad (1/\phi\ \mathbf{f}\ \mathbf{L}\,)\,\mathbf{N} \tag{5.19}$$

From equation (5.17):

$$(1/\phi\ \mathbf{f}\ \mathbf{L}\,)\,\mathbf{N} \quad = \quad 1/\phi\ \mathbf{f}\ \mathbf{F} \tag{5.20}$$

Thus the vector **f** maps back to the vector ($1/\phi$ **f F**). It is logical for any rational pricing system for the factors of production that **f** should map back to itself, therefore any discrepancy between **f** and ($1/\phi$ **f F**) may be taken as a derogation from rationality.

From the above the following two equations should hold:

$$\mathbf{f} \quad = \quad 1/\phi\ \mathbf{f}\ \mathbf{F} \tag{5.21}$$

$$\mathbf{p} \quad = \quad 1/\phi\ \mathbf{p\,NL} \quad = \quad 1/\phi\ \mathbf{p\,P} \tag{5.22}$$

It is clear that unless a particular set of factor weightings are chosen; the result of this reflexive mapping will generally deviate from **f** and **p**.

If, however, the initial choice for **f** corresponded to an eigenvector or latent vector of the matrix **F**, then it will map back to itself. Similarly if the choice for **p** corresponds to the eigenvector of the matrix **P** then it will also map to itself. To solve the above equations in a non-trivial way, the cost/turnover ratio (ϕ) must be chosen so that it will correspond to the associated eigenvalue.

The eigenvalue or latent root of a matrix **M** may be defined as a scalar ε, which if deducted from the leading diagonal of the matrix will give a zero determinant (Glaister, 1980):

$$|\mathbf{M} - \varepsilon \mathbf{I}| = 0 \tag{5.22}$$

It should be emphasized that an [N x N] matrix there will be N eigenvalues. However since some of these may be duplicates and some may be negative and others complex, to make sense the *dominant* (largest) eigenvalue must be selected.

A *(right hand)* eigenvector (**x**) will be associated with each eigenvalue, and may be defined thus (Glaister, 1980):

$$[\mathbf{M} - \varepsilon \mathbf{I}]\mathbf{x} = \mathbf{O} \tag{5.23}$$

where $\mathbf{O}$ = zero matrix

In the case of the *left-hand* eigenvector (**y**), the following would apply

$$\mathbf{y}[\mathbf{M} - \varepsilon \mathbf{I}] = \mathbf{O} \tag{5.24}$$

The dominant eigenvalue of both matrices **F** and **P** will correspond to ϕ^*. The dominant left-hand eigenvector of **F** should correspond to the row vector $\mathbf{f}^*$ while for **P** it will be the row vector $\mathbf{p}^*$.

5.2.6: Computation of eigenprices

Calculation of eigenvalues and eigenvectors can prove problematical for any non-trivial matrix. To solve them symbolically is totally uneconomical, since direct expansion of the characteristic polynomial $|\mathbf{M} - \varepsilon\, \mathbf{I}|$ is extremely labourious, and therefore a numerical solution using some type of iteration process is usually favoured.

The problem with any numerical methods is that the linear equations generated are prone to *ill-conditioning*; here a very small (rounding) error in the computation can lead to very large errors in the solution. Even worse if the wrong iterative scheme is employed this can lead to *induced instability* in the model. See Chapter 9 for a discussion of ill-conditioning and induced instability.

For the calculation of the dominant eigenvalue, direct iteration should give virtually no induced instability. The accuracy of the computation of the associated eigen-vectors will depend upon the inherent stability (ill-conditioning) of the model. The iterative approach employed by Seton (1985) will be outlined in Chapter 8.

The next problem concerns the *scale* of the eigenvectors $\mathbf{f}^*$ and $\mathbf{p}^*$ to be used to compute the eigenprices for factors and products respectively. From standard linear algebra, eigenvectors are not defined in absolute values but are only determinate up to a scalar multiple. Thus if $\mathbf{f}^*$ will satisfy the conditions then so will $\mu\, \mathbf{f}^*$ or $\upsilon\, \mathbf{f}^*$ (Glaister, 1980). *Scale* may be fixed to ensure that the *eigensurplus* or sum of all *markups* is equal to the sum of the original residual row (τ). This has the advantage of yielding eigenprices with a weighted mean equal to unity. The 'surplus' generated by the economic system is thus merely redistributed by repricing in eigenprices and is not altered ¶.

¶ Thus the overall rate of indirect taxes less subsidies would not be affected; however instead of the rate varying from industry to industry, the overall rate would be imposed on each industry.

The elements of the eigenvectors **f*** and **p*** scaled as above, will have values near to unity and thus the eigenprices will be sufficiently close to market prices to ease comparison. The eigenvectors **f*** and **p*** are transposed to give us the *standardized* eigenprices for each row of the input-output table. The elements in the transposed vectors $\mathbf{f}^{*T}$ and $\mathbf{p}^{*T}$ are used as multipliers to reprice the original table in eigenprices. The rows [1 to N] in the table corresponding to intermediate flow and final uses (uadrants I and II) use the transposed vector $\mathbf{p}^{*T}$. Rows [1 to P], corresponding to value added (uadrant III), use the transposed matrix $\mathbf{f}^{*T}$. The total input row ($\mathbf{z}_j$) is taken as the transpose of the total output column ($\mathbf{z}_i$) and the 'mark-up' row (τ) is taken as the residue to ensure that the column sums correctly to the total input row ($\mathbf{z}_j$).

5.3: INTERPRETATION OF THE MODEL

5.3.1: Parallels to conventional economic analysis

Seton (1985) makes several claims for the model in terms of its relationship to conventional economic analysis. The following are examples:

i) The (pre-input-output) neo-Classical models dispense with any considerations of intersectoral flows. They treat the production process as the direct transformation of primary inputs into final commodities — *eg.* feedback-free models — and they can be represented by setting the intermediate flows (x_{ij}) to zero. This effectively replaces the Leontief inverse with the identity matrix. This model trivializes the eigenprices out of existence by setting them equal to marginal costs.

ii) Conventional models of marginal analysis can be linked to the approach by treating the derivation of full cost and use-norm prices as dual solutions to a linear programming problem:

$$\textit{minimize}\quad \mathbf{f\,v}\quad \textit{subject to}\quad \mathbf{v} > \mathbf{L\,y} \tag{5.25}$$

$$\textit{maximize}\quad \mathbf{c\,y}\quad \textit{subject to}\quad \mathbf{c} < \mathbf{f\,L} \tag{5.26}$$

iii) The Sraffa type approach – those models assume that commodities are produced by means of commodities only (factor-free models). This approach can be approximated by the deletion of the third quadrant (value added) from the model and its direct replacement by a direct emanation of the intersectoral flows. The idea is that *"value added is dependent not on any importation of inputs from outside the sectoral system, but on a spontaneous secretion of the material inputs themselves"* (Seton, 1985).

iv) Marxian labour values can be replicated by eliminating all factors other than labour. In addition, other changes will be necessary including dispensing with use-norming and restricting operations to 'downstream' transformations. The factor prices would either be based on market prices or on the decisions of the price bureau for a command economy. Alternatively it could be based on the Marxist criteria of *alienation*. The latter approach would take cost-fetishism to its ultimate conclusion and set wages effectively at subsistence level marked up by a uniform 'rate of exploitation' applied to all product costings.

5.3.2: Interpretation of eigenprices and eigenyield

Seton (1985) identifies the eigensurplus or eigencost ratio ($\sigma^* = 1/\phi^* - 1$) which represents the proportion of the eigenprice withheld from the factors of production. It will accrue either to the government (indirect taxation) or to other agents as supernormal profits, extortion, or pricing errors by governmental agencies. This concept has some similarities to the Marxist 'rate of exploitation' although without the single-factor theory of value or any notion of class exploitation.

He is, however, on much weaker ground in attempting to assert that the ratio (σ^*) is a measure of the excess value that the system can yield beyond the necessary rewards to factors of production. Thus an 'efficient' economy is one that can extract a higher level of *'ad valoren'* surplus. This has parallels to the way that an efficient company operating in a competitive environment can extract a higher profit margin than its less efficient contemporaries.

Eigenprices below unity will imply positive eigensurplus, and would suggest some degree of pre-tax expropriation or alienation of primary factor providers in favour of 'someone else'. This might be the 'government' (taxation, excess defence spending), the 'community' (social spending, transfer payments), 'other countries' (running up trade surplus, buying up overseas assets), the 'future' (investment). By contrast, a ratio above unity implies some element of subsidy of factor providers by others. This may take the form of using past credits (consuming capital), storing up problems for the future (increasing national debt), or relying on other countries (running trade deficits, selling overseas assets).

The problem with taking the eigensurplus ratio or *eigenyield* as an indicator of the performance of the economy is that it is too bound up with the overall rate of indirect taxation. Thus a country with high direct (income) taxation and low indirect (expenditure) taxation would tend to have a higher eigenyield than a country where most revenue was raised from the latter. This is implicit in the scaling of the eigenvectors to leave the total surplus unaffected by the repricing involved.

In empirical studies by Seton (1981, 1985), the model produced some quite bizarre results. The ranking of countries, in terms of eigenyield, come out roughly in the reverse order to that expected, apart from the UK finishing at the bottom of the 'league table'! Czechoslovakia finished first, while the Federal Republic of Germany and Japan came lowest, apart from the USSR and UK; this suggests that the unadjusted eigenyield is fatally flawed for international comparison.

5.3.3: Price deviancy

This is a measure of the weighted deviation, from mean, of the industrial eigenprices; the implication is, that an economy displaying little price deviancy is internally competitive between different industries. The initial results from Seton's analysis show the UK with the lowest values for price deviancy with the eigenprices remarkably near to market prices.

5.4: EIGENPRICES AND THEIR USE FOR COMPARISON

5.4.1: Introduction

There are objections to the use of eigenyields as the basis for international comparisons. The model is much stronger in terms of intersectoral comparisons, and for international comparisons based on such. The possible uses of the model for the three main categories of comparison are outlined in Chapter 1. If nothing else, the standardized eigenvectors take account of, and correct for, differential tax rates repricing all industries and substituting a uniform 'tax' rate. The approach is worthy of consideration for that feature alone.

5.4.2: Inter-industrial comparisons

This would entail the examination of 'underpricing' and 'overpricing' of factors and commodities, within a given economy. This would expose the incidence of discriminatory taxation policies and its impact on commodity pricing. For example in the UK before the mid-1960s manufactured goods were taxed *via* Purchase Tax, car tax, excise duty *etc.* while the service industries remained untaxed until the introduction of SET (Selective Employment Tax) and its subsequent replacement by VAT (Value Added Tax). Equally two specific sectors —agriculture and coal production —have a history of subsidised production over a long period in the UK and throughout the European Community. Repricing with eigenprices should ensure a better comparison.

5.4.3: International comparisons

International comparisons using the model will be appropriate if the emphasis is on industrial comparisons between different countries. Thus if it was desired to compare highly-subsidised agricultural productivity in one country with that of another country with less subsidy, the schema repriced in eigenprices might be expected to provide for a better comparison.

5.4.4: Time-series comparisons

The model clearly has uses for time-series comparisons particularly when tracking industries over time under different taxation and/or subsidy regimes. Thus it should identify the impact of the creeping introduction of VAT to construction works over the years and the implications of the phasing out of coal production subsidies that commenced in earnest in the 1980s. Subsequently, the effects of any successful reform of the Common Agricultural Policy could prove illuminating.

5.4.5: Conclusion

Some use will be made Seton's approach in the proposed model. The features to be employed will be outlined in the next Chapter. It involves repricing the capital 'inputs' into the productive process using the eigenprice associated with the industry responsible for the production of each type of asset. The profit 'output' is scaled using the eigenprice associated with the 'profit' row in the value added quadrant. Other issues will be discussed concerning the implementation in Chapter 8.

CHAPTER NO 6:

THE PROPOSED MODEL

The employment of mathematical symbols is perfectly natural when the relations between magnitudes are under discussion, and even if they are not rigorously necessary, it would hardly be reasonable to reject them ... if they are able to facilitate the exposition of problems to render it more concise, to open the way to more extended developments and avoid the digressions of vague argumentation.

Antoine Augustin Cournot

This Chapter draws together the key features of the proposed approach to the measurement of capital productivity. This is based on the model outlined in Chapter No 3 with modification proposed in Chapters No 4 and 5. The computational formulæ are presented in algebraic form.

6.1: RESUMÉ

6.1.1: Objectives

The objective set out in Chapter 1 was to produce a framework suitable for the measurement of comparative performance of the construction industry across time, space, and economic systems. Various approaches to productivity measurement were discussed in Chapter No 2 against the desired objectives; notably the minimization of use of what was identified as sources of instability — currency exchange rates and index numbers. Only capital productivity came anywhere near meeting the above requirement. Several theoretical and practical difficulties were encountered with the formulation of capital productivity. The next three Chapters discussed the modification of the theory of capital productivity to take account of these problems — both general and specific to construction.

The immediate task involves the formulation of a formal mathematical model consistent, with the theories expounded in the previous Chapters.

6.1.2: General approach

The unifying principle behind the methodology is input-output analysis, which is described by one commentator as: *"a quasi-engineering approach to economics"* (Seton, 1985). Chapter 3 outlines the view of capital productivity as a cash flow based input-output process. The *inputs* are 'investment flows' while the *outputs* are the 'profit stream'. The productivity of the above process is seen as the efficiency by which *inputs* are converted into *outputs*.

Direct comparison of the two flows is clearly ruled out since the investment pattern is liable to be 'lumpy'. There is no guarantee that the returns in any given year will bear any relationship to the investment in that year. In any event, certain fixed capital assets (*e.g.* the purchase of new head office block) have a very long life span while others are short-lived (*e.g.* buying a new site van).

Thus in the tradition of investment appraisal a discounted cash flow approach is suggested such that the future profit stream and the past investment flows are discounted to present values. This involves selecting a suitable depreciation rate for all fixed capital assets to estimate the earning capacity of an item of fixed capital.

The problem associated with capital productivity of 'valuing the stock of fixed capital' is sidestepped by removing from the model any notion of attempting to value physical assets. Instead, the notional 'capital stock' is simply a discounted vector of past investments in the various categories, taking account of an anticipated notional depreciation rate. The 'discount rate' for past investments is taken as the inflation rate effecting capital assets while the 'discount rate' for the 'profit stream' is the measure of capital productivity that we are seeking. Working capital is included as an element in the capital vector.

6.1.3: Direct and indirect capital

A major problem with traditional productivity measures taking value added divided by direct inputs as the basis of measurement is the exclusion consideration of indirect contributions to output. In the case of construction, with much work being shifted from the site to the factory (particularly in housing), it is possible that construction productivity could eventually be trivialized out of existence ¶.

To take account of these indirect contributions, Chapter 4 proposes that the Leontief input-output approach is used to 'synthesize' total capital contributions from the direct inputs. The general productivity ratio takes gross output by 'direct and indirect inputs'. For capital productivity it is total (direct and indirect profits) by total capital.

¶ This would imply that more and more of both labour and capital associated with the construction of built assets is being shifted off-site, thus leaving the rump of work carried out on-site and classified to 'Construction' as unrepresentative of the total 'process' of construction.

6.1.4: Eigenprices

Residual doubts remain about the suitability of using *raw* market prices as the basis for a rational consideration of economic efficiency given that different sectors are subjected to differential rates of indirect taxation. Chapter 5 suggests that the input-output schema be repriced using Seton's (1985) eigenprice approach.

6.2: OUTLINE OF THE MODEL

6.2.1: Components

The model has four basic parts. First, an input-output table is needed to enable the synthesization of total contribution of capital to construction and the total profits generated. Second, a component is required to calculate a matrix of the present values of past investment flows for each category of capital and for each industry contributing directly or indirectly to construction. Third, a method of generating direct profits is needed. Finally, there is the component that calculates the discounted profit rate, the measure of productivity selected.

6.2.2: The input-output table

This first stage involves the calculation of the (supply-side) Leontief inverse matrix $[I - B]^{-1}$ from the input-output table provided in official statistics. The initial tableau should also be modified to reprice in eigenprices as outlined in Chapter 5. This involves taking the published industry-by-industry tableau and row normalizing by the eigenprice vectors **p** and **f** for the [N] industry rows and the [P] primary input rows respectively. It should be noted that since the scaling is conducted by rows, this will preserve the output structure of the industry and leave the (supply side) Leontief inverse unaffected ¶.

¶ The more commonly used (demand side) Leontief inverse will however be affected by the scaling process; the input structure is, consequently, changed by the scaling.

The eigenvectors **p** and **f** must be calculated. The following iterative approach, which relies on the reflexive mapping back properties of the vectors, is used.

The first round of the iterative process may proceed by taking an estimated value for f. The unit vector should suffice for this purpose.

$$\mathbf{p}_1 = \mathbf{f}_0 \mathbf{L} \quad \text{and}$$
$$\mathbf{f}_1 = \mathbf{p}_1 \mathbf{N} \tag{6.1}$$

where $\mathbf{f}_0 = \mathbf{u} =$ unit row vector [1,1,1,...,1] [1 x P]

The general form of the iterative process becomes:

$$\mathbf{f}_{r+1} = \mathbf{p}_{r+1} \mathbf{N} = \mathbf{p}_{r+1} = \mathbf{f}_r \mathbf{L} \tag{6.2}$$

Thus cost and norm factors are generated alternately by the process, it should continue until the process stabilizes thus:

$$\lim_{r \to R} \mathbf{f}_{r+1} = \phi * \mathbf{f}_r \tag{6.3}$$

The ratio between successive rounds of the iteration process should stabilize at ϕ, the dominant eigenvalue of both **F** and **P**. The vectors $\mathbf{f}_R$ and $\mathbf{p}_R$ will constitute left-hand eigenvectors for **F** and **P** respectively. It is now necessary to scale the eigenvectors to unity to ensure that the national income and total 'markup' is left unaffected by the process. This is accomplished by devising scalars ν and ω for $\mathbf{f}_R$ and $\mathbf{p}_R$ respectively.

$$\nu = (1/v)\phi\, \mathbf{f}_R\, \mathbf{w} \tag{6.4}$$

$$\omega = (1/v)\mathbf{f}_R\, \mathbf{w} \tag{6.5}$$

where $\mathbf{w}$ = column vector of value added by income type [P x 1]

$(1/v)$ = scalar of reciprocal of total value added

The supply-side Leontief inverse matrix $[\mathbf{I} - \mathbf{B}]^{-1}$ should then be used to synthesize the matrix representing the total requirements for capital from the matrix of direct usage of capital $\mathbf{K}_t$ for each year (t) being studied. It will also identify the total profits accruing to the construction process.

6.2.3: Calculation of the capital matrix

Calculation will be best accomplished in two stages. The first stage is the identification of the valuation of the matrix at the start of the time frame from published statistics and subdividing it into [N] industries and [R] capital types. The degree of articulation in each case will depend on the particular study being carried out and the availability of data.

As well as fixed capital formation, allowance should be made for any changes in the value of stocks of unfixed goods and materials, fuels and consumables, plus work-in-progress and unsold but completed buildings. The total valuation of investment in working capital can be taken as an additional type of capital.

The methodology employed in the actual subdivision of the data will depend upon the degree of articulation selected and the information provided in the published sources. If insufficient data is available in the original published sources then additional information may be obtained from other published material and historical texts such as that by Feinstein (1972) or other official statistics such as input-output tables. An approach to this problem will be given in Chapter 7.

The second stage involves the updating of the initial matrix to take account of new investment, depreciation and a changing price base. This will be best carried out separately as a [1 x R] column vector for each of [N] industries. The recursive formula derived from equation (3.3) is used thus:

$$\mathbf{k}_{jt} \quad = \quad p_t \, \mathbf{k}_{jt-1} \hat{\mathbf{D}}' + \mathbf{c}_{jt} \qquad (6.6)$$

where: $\mathbf{k}_{jt}$ = column vector of capital for industry j in year t [1 x R]

$\mathbf{c}_{jt}$ = column vector of investment for industry j in year t [1 x R]

$\hat{\mathbf{D}}'$ = diagonal matrix to represent depreciation with elements $(1\text{-}\delta_{it})$ on leading diagonal [R x R]

p_t = scalar of price index movements from year t-1 to year t

δ_{it} = scalar of depreciation for capital category i in year t

The above when completed for [N] industries will aggregate to an [N x R] matrix of capital for year t.

$$\mathbf{K}_t \quad = \quad \sum_{j=1}^{N} \mathbf{k}_{jt} \quad + \quad \omega_t \qquad (6.7)$$

where $\mathbf{K}_t$ = capital matrix for year t [N x R]

ω_t = working capital column vector for year t [N x 1]¶

This should be repeated for [Q] years to produce [Q] separate [N x R] matrices.

¶ Working capital can either be measured directly or taken from the working capital for the previous year with allowance for changes in stockholding in materials, goods, and products over the time period.

The capital matrix should be synthesized into total (direct and indirect) capital use matrix thus:

$$\mathbf{K}^*_t \quad = \quad \mathbf{K}_t[\mathbf{I} - \mathbf{B}]^{-1} \qquad (6.8)$$

where $\mathbf{K}^*_t$ = total capital matrix for year t [N x R]

The capital stock should be adjusted into eigenprices by scaling its elements by the appropriate element of the eigenprice vector **p**. Each column of the capital matrix is multiplied by the scalar p_j the element of the eigenprice vector associated with the industrial group of its production, apart from the working capital column. For the latter each row is scaled by p_i the element of the eigenprice vector associated with the stockholding industry.

This is best carried out by partitioning the capital matrix into three submatrices corresponding to the different industries responsible for the creation of each capital type. It is difficult to generalize a method for accomplishment of this task without details of the articulation of the capital matrix into capital types and industries. For the categories used within the Case Study, the subdivisions would be constructed facilities, manufactured equipment, and working capital:

$$\mathbf{K} \quad = \quad \mathbf{K}_c \quad + \quad \mathbf{K}_m \quad + \quad \mathbf{K}_w \qquad (6.9)$$

where $\mathbf{K}_c$ = submatrix of capital in the form of constructed facilities [N x 2]

$\mathbf{K}_m$ = submatrix of capital in the form of manufactured equipment [N x 8]

$\mathbf{K}_w$ = submatrix of capital in the form of working capital [N x 1]

i) Constructed facilities (Real estate and dwellings) – an [N x 2] sub-matrix. This is adjusted by the scalar p_c the eigenprice associated with construction thus:

$$\mathbf{K'}_c = p_c \mathbf{K}_c \qquad (6.10)$$

where p_c = scalar of the element of the eigenprice vector corresponding to construction

$\mathbf{K'}_c$ = submatrix of constructed facilities scaled into eigenprices [N x 2]

ii) Manufactured equipment (Plant, equipment and vehicles) – an [N x 8] sub-matrix. This is adjusted by the scalar p_m the eigenprice associated with manufacture thus:

$$\mathbf{K'}_m = p_m \mathbf{K}_m \qquad (6.11)$$

where p_m = scalar of the element of the eigenprice vector corresponding to manufacture

$\mathbf{K'}_m$ = submatrix of manufactured equipment scaled into eigenprices [N x 8]

iii) Working capital – an [N x 1] submatrix. This should be scaled by the eigenprice associated with the working capital of each industry within it.

$$\mathbf{K'}_w = \hat{\mathbf{P}} \mathbf{K}_w \qquad (6.12)$$

where $\hat{\mathbf{P}}$ = diagonal matrix consisting of the elements of the vector **p** on the leading diagonal

$\mathbf{K'}_w$ = submatrix of working capital scaled into eigenprices [N x 1]

Thus the capital matrix can be reaggregated:

$$\mathbf{K'} = \mathbf{K'}_c + \mathbf{K'}_m + \mathbf{K'}_w \tag{6.13}$$

where $\mathbf{K'}$ = capital matrix scaled into eigenprices

This can then be synthesized into total capital usage thus:

$$\mathbf{K'^*}_t = \mathbf{K'}_t[\mathbf{I} - \mathbf{B}]^{-1} \tag{6.14}$$

where $\mathbf{K'^*}_t$ = total capital matrix for year t [N X R] scaled into eigenprices.

6.2.4: Calculation of the profit

The next step is to identify the profit element (direct and indirect) associated with construction. This will form a part of the gross output (z_i) which is presented as an integral part of the input-output tableau. In the same way that the gross output vector (**z**) can be synthesized from the value added vector (**v**) using the $[\mathbf{I} - \mathbf{B}]^{-1}$ matrix, the total (direct and indirect) profit vector (π) can be synthesized from the direct profit vector ($\mathbf{v}_k$)

$$\pi = \mathbf{v}_k\,[\mathbf{I} - \mathbf{B}]^{-1} \tag{6.15}$$

where π = total profit row vector [1 X N]

$\mathbf{v}_k$ = direct profit row vector corresponding to the k*th* row of **V** [1 X N]

If scaled into eigenprices, this becomes:

$$\pi' \quad = \quad f_k v_k \ [\mathbf{I} - \mathbf{B}]^{-1} \qquad (6.16)$$

where f_k = scalar of eigenprice for profits
π' = total scaled profit row vector [1 x N]

This stage must be repeated for each year under consideration.

6.2.5: Computation of the discount rate

The final step in our operation is the computation of the discount rate. It should by now be apparent that we have sufficient data to calculate the discount rate for each of the [N] industries within the economy. This is because we have an [N x R] matrix of capital stock of [R] capital types and [N] industries and a [1 x N] vector of total profit for each of [N] industries. While the original intent may have been to provide figures only for the construction industry, it would appear logical to perform the computation for all of the industrial groups ¶.

To remind ourselves of the definition from equations (3.19) and (3.21)

$$\delta_j \quad = \quad \frac{\sum_{i=1}^{R} \delta_i \kappa^*_{ij}}{\sum_{i=1}^{R} \kappa^*_{ij}} \qquad (6.17)$$

where δ_j = composite depreciation rate for industry j
δ_i = depreciation rate for capital type i
κ^*_{ij} = total capital type i invested in industry j

¶ The calculation of the return on capital for all industrial groups facilitates inter-industrial comparison for the broad industrial groupings as well as a time-series analysis of construction.

$$\lambda_j \quad = \quad (\gamma_j - \delta_j) \tag{6.18}$$

where λ_j = discount rate for industry j
γ_j = overall rate of return on all capital invested in industry j

$$\gamma_j \quad = \quad \pi_j \, / \, \sum_{i=1}^{R} k^*_{ij} \tag{6.19}$$

As a preliminary to the calculation of the discount rate, the overall rate of return and the composite depreciation rate should be computed thus:

$$\mathbf{k^*}_j \quad = \quad \mathbf{u\,K^*} \tag{6.20}$$

where $\mathbf{k^*}_j$ = row vector of total capital in each industry [1 x N]
$\mathbf{u}$ = unit row vector [1,1, ... ,1] [1 x N]

$$\boldsymbol{\delta}_j \quad = \quad \boldsymbol{\delta}_i \; \mathbf{K^*} \; \mathbf{\hat{K}^*}^{-1} \tag{6.21}$$

where $\mathbf{\hat{K}^*}^{-1}$ = inverse of diagonal matrix with elements of $\mathbf{k^*}_j$ on leading diagonal [N x N]
$\boldsymbol{\delta}_j$ = row vector of composite depreciation rates for each industry j [1 x N]
$\boldsymbol{\delta}_i$ = row vector of depreciation rates for each capital type i [1 x N]

The next step is to calculate the overall rate of return and the discount rate for each industry using the following approach:

$$\gamma \quad = \quad \pi \hat{K}^{*\,-1} \tag{6.22}$$

$$\lambda \quad = \quad \gamma - \delta \tag{6.23}$$

where γ = row vector of total return on capital for each industry j [1 x N]

λ = row vector of discount rate for each industry j [1 x N]

The discount rate vector calculated (λ), or more precisely, the element associated with the construction product (λ_j) is the basis used for comparison. The above procedure is repeated using capital and profits scaled into eigenprices from equations (6.14) and (6.16).

Since this approach represents a single-factor measure of productivity, the various caveats identified in Chapter 2 should be emphasized, particularly regarding attempts to compare sectors with fundamentally different industrial structures.

6.3: TESTING THE MODEL

6.3.1: Generally

The key point about testing such a model, as outlined in the Prolegomena, is that it cannot be tested by comparing results against some preconceived notion of what the results 'ought to be'. Its validity as a model depends essentially on how far it meets its original objectives and the internal logic of its construction. The extent to which it follows the current approach of a coherent school of economic thought is also relevant. The fact that the results so generated may deviate from conventional wisdom is no reason to reject the model unless the outcome is bizarre in the extreme. See the example cited in Chapter 5, where Seton's (1985) eigenyield 'league table' put Stalinist Czechoslovakia in first position. Even so there may be reasons for such results, for example the incompatibility of statistics, or the use of state power to keep living standards low and thus allow the state to extract a high surplus. There are few certainties in economic theory and practice.

6.3.2: The Case Study

The above should not be taken to imply that no empirical work need be undertaken. Clearly the model will fail if it proves impossible to implement it using real as opposed to simulated data. For the above reason, an inter-industrial and time-series comparative case study will be undertaken using the U.K. as the base. It would have been useful to undertake an international comparison involving three or four countries. This would present problems in terms of collecting, and more especially, understanding the (incompatible) statistics from different counties within the time available for this stage of the study.

Clearly, if the statistics are not directly compatible, such comparisons will, inevitably, be problematical. The difficulties encountered by Seton (1980, 1985) in his international comparisons illustrate the inherent problems. There were sufficient impediments encountered in the single country Case Study outlined in Chapters 7 and 8 in dealing with a changing basis for collecting and reporting economic statistics over a 40 year period.

6.3.3: Validating the model

Clearly the first hurdle that the model must overcome is the test; "can it be implemented?" The Case Study, presented in Chapters 7 and 8, deals with this problem. Clearly other hurdles remain, particularly those of traditional notions of compliance with *scientific method*. These issues will be discussed in Chapter 10 in the context of the Case Study results.

CHAPTER NO 7:

DATA SOURCES

There are three kinds of lies:
lies, damned lies, and statistics

Mark Twain

This Chapter introduces the sources of data that are available in order to conduct a time-series Case Study of UK productivity over a fourty year period. The problems with the use of such data and their reliability is discussed in detail.

7.1: INTRODUCTION

7.1.1: Data requirements for the case study

As indicated in Chapter 6, the model is to be partially tested *via* an inter-industrial and time-series Case Study of the UK from 1948 to 1990. The main emphasis is on the later years from 1968 on and less there is less confidence on the results from the early years. The Case Study poses a number of problems in terms of data collection. All data used is based on official and semi-official sources. Most is taken from the publications of the Government Statistical Service (GSS) and associated academic publications, *e.g.* Feinstein (1972).

This includes national income accounting data in both conventional and input-output format. In addition, information on investment and capital values will be needed over a considerable period.

7.1.2: Type of data needed

It is possible to distinguish several distinct data types required for the Case Study:

a) First, there is data that may be regarded as factual. This includes national income figures on output, investment, and inter-industrial flows. The inevitable problem with this type of data is inaccuracy. This stems from the method of collection and publication of such data by the CSO and other central government agencies.

b) Second, there is data, although published with accuracy and precision and updated frequently, is subject to regular fluctuations. Interest rates and currency exchange rates are the principle examples of this category.

c) Third, there is information derived from other statistical data using subjective criteria. This would include cost and price indices. They are usually based on a weighted average of different components, and are thus objective in terms of computation but highly subjective in terms of selection and weighting of the elements.

d) Fourth, there is derived data that are based on objective criteria and well understood in terms of the process of derivation. Examples include the industry-by-industry domestic flow matrices presented in input-output tables.

e) Finally, there is objectively derived data that is not presented in a suitable format for use in the Study. Much of the derived information published by the GSS is either provided in the wrong format, or with insufficient detail. In some cases, there may be doubts regarding the accuracy of the data.

7.1.3: The use of published statistical data

As indicated in Chapter 1 of this Thesis, the aim is to avoid the use of transitory information, liable to fluctuation, *e.g.* currency exchange rates. Similarly, it was intended to minimize the use of subjectively derived data, *e.g.* index numbers. The Case Study will be based, as far as possible, on the first and fourth categories of information. If data has to be derived, it is essential to fully understand the basis of the derivation and the assumptions made.

Obviously, it is both impractical and unnecessary to reconstitute all derived data, especially where there is little room for debate, or if the method of construction is well understood. However, in certain other cases, the derivations are carried out specifically for this analysis.

Thus, the industry-by-industry flow matrix — that is used for the input-output operations – is derived from three basic tables: the make matrix, the absorption (or 'use') matrix, and the imports matrix. Here, there would be little point in replicating the above derivation since. While mistakes and inaccuracies can exist, as discussed later this Chapter, these will be most likely in the construction of the basic tables instead of in the subsequent derivation process.

By contrast, the estimate of the capital matrix is calculated from the basic information. There are figures on the capital stock of the UK, published annually in the *Blue Book*, but they are far from satisfactory for the purpose in hand. They are not as reliable as most national income data (See Table 7.6.2 below). It can be argued that the assumptions used in their valuation cause most difficulties.

a) First, all assets are assumed to have (very long) finite life spans and are valued **gross** at current replacement costs until deemed to be scrapped (CSO, 1985). In practice most capital items will depreciate due to obsolescence — inability to compete with more modern and efficient hardware — long before they are physically worn out. A **net** measure of the *capital stock*, based on resale values will be of more use for measuring capital productivity.

b) Second, the *Blue Book* data is not disaggregated into the different capital types except manufacturing, which is split into three basic categories: land & buildings, vehicles, and plant & equipment.

In such cases, the derived data is calculated specifically for the Case Study. The prime example here is that of depreciation of fixed assets and the concomitant issue of capital valuation. Sometimes, the national income data and input-output data may not be in the correct format for the needs of this Study and partial reconstitution is required.

The problems encountered with the use of such published data are sufficient to warrant detailed discussion in this Chapter before the commencement of the Case Study. This Chapter should be seen as an integral part of the Case Study instead of part of the 'theory' component of the Thesis. It is based largely on United Kingdom statistical sources and does not have the general applicability of the theoretical model. Having said that, the problems concerning official statistics in the UK are similar to those identified in other European Community countries and elsewhere in the world.

7.2: ECONOMIC STATISTICS SOURCES IN THE UK

7.2.1: The Government Statistical Service

While all official statistics in the UK emanating from the GSS and published by HMSO, several different departments and groups are involved. Most notable are the Central Statistical Office (CSO) which deals with National Income data, and the Business Statistics Office (BSO) of the Department of Trade and Industry which deals with the Census of Production. There is also the Department of the Environment (DoE), who with the Scottish Development Department and the Welsh Office produce data on the construction industry for Great Britain. Data on the construction industry in Northern Ireland is published separately ¶.

7.2.2: General economic data

Several official publications from the GSS are published by HMSO on general economic issues. They include some data on the construction industry and its relationship to the rest of the economy.

The most useful of these are as follows:

¶ The Northern Ireland Annual Abstract of Statistics published by the Department of Finance and Personnel, Stormont, Northern Ireland.

a) ***UK National Accounts:*** Formerly known as National Income and Accounts it is usually called the *Blue Book.* It is published annually by the CSO, and includes data on the key economic aggregates. This includes the share of Gross Domestic Product accruing to each of the broad industrial groups.

b) ***Economic Trends:*** Published monthly with an Annual Supplement by the CSO. It includes many long series of general economic data along with specialized articles on important issues. Much of the data published in the Annual Supplement is too general to be of much use for this Thesis.

c) ***Input-Output Tables:*** Published around every four to five years by the CSO, with updated tables occasionally issued on an annual basis. They include detailed information on the inter-relationship between the various sectors of the economy.

d) ***Regional Trends:*** Published annually by the CSO, they consolidate a variety of regionally related economic and social statistical data. Some details of the construction industry are included in such areas as regional share of gross domestic product, employment, *etc.*

e) ***Business Monitor:*** This is also published annually by the Business Statistics Office (BSO) of the Department of Trade and Industry ¶. It covers the production (energy and manufacturing), and construction industries. This is based on the Census of Production, which relies upon a full survey in each 'benchmark' year (every four to five years) and a partial survey in intermediate years. Information is also given on the distribution industries taken from the Census of Distribution.

¶ This refers to the PA series of Annual reports on the Production and Construction industries. Other series include the PQ series which are published Quarterly.

7.2.2: Construction industry data

There are two major sources of data specifically on the construction industry as published by HMSO:

a) ***Housing and Construction Statistics:*** This is published quarterly with an annual supplement by the DoE, the Scottish Development Department and the Welsh Office. It contains a variety of information on the construction industry for England, Scotland, and Wales; Northern Ireland is excluded. It covers work by registered firms with estimates for unregistered firms on such issues as gross output, employment, cost indices, orders received, *etc.*

b) ***Business Monitor PA 500:*** This is published annually by the BSO of the Department of Trade and Industry. It covers data on orders, output, employment, investment, and stocks. Unlike *Housing and Construction Statistics*, *Business Monitor* covers the whole of the UK but is restricted to registered firms. While estimates are made to cover non-responders and for incorrectly filled-in forms, no allowance is made for the many unregistered (labour-only?) subcontractors, who form the fastest growing sector of the UK construction industry.

Besides the official statistics, there is a range of publications from contractors' associations, building material producers, professional institutes, etc., that contain data on the construction industry. The RICS *Building Cost Information Service* falls within this category.

Finally, semi-official statistics are published by organizations such as the National Economic Development Office ¶, for example price indices, *etc.*

¶ The National Economic Development Office (NEDO)

7.2.3: Problems with published statistics

The use of such secondary data presents certain problems. Typically, there are discrepancies between different data series and even within series. Sometimes these problems can be explained by different sampling frames, *e.g.* the inclusion of data on Northern Ireland and/or unregistered firms. In other cases there appears to be no logical explanation other than fundamental differences in definitions and methods of data collection or even major errors in the sampling procedure or the processing of data.

It is impossible to carry out any macro-economic study of the construction industry without resorting to such statistics. Thus they remain an essential resource but the results should be treated with some caution. To minimize error, a single data source should be used consistently over a time-series instead of *mixing* different data series.

7.3: DATA SOURCES CONSULTED

7.3.1: Introduction

Since only a limited subset of the vast array of official and semi-official statistics will be consulted, there is little point in discussing the accuracy and precision of sources not used. Consequently, the data used is outlined and the sources identified before the analysis of specific publications and series.

The information needed for productivity measurement as employed in this Thesis comes in three categories representing the Output/Input ratio identified in Chapter 3 and the Input-output relationships covered by Chapters 4 and 5:

a) **Output data** – the gross company profits plus public enterprise surplus, rental income, and imputed allowances for capital usage made by the broad industrial groups.

b) **Input data** – investment in fixed capital and stockbuilding used by the broad industrial groups.

c) **Input-output data** – showing the key interdependencies between the different industrial groups, etc.

The Case Study in this Thesis is based as far as possible on National Income statistics and Input-output tables. There are alternative sources for some of the data series often providing greater detail, notably the Census of Production and the Census of Distribution published in *Business Monitor.* However, there are discrepancies between different data series. The *Blue Book* provides a level of consistency across the various industries that cannot be matched by Census of Production data. The Input-output tables are derived from and consistent with National Income statistics. Thus these figures should, at least, be internally consistent between industries, even if not so across time.

7.3.2: National Income Data

The *Blue Book* has been published since 1952 and contains data on value added, and investment presented by industry and by asset type, going back to 1948. Before that, little official national income data is available. Much of the earlier information has been collated and published by the Department of Applied Economics at the University of Cambridge in association with the National Institute for Economic and Social Research in a series of books ¶.

The *Blue Book* normally presents data in an 11-year time-series with a one year lag. Thus the 1991 edition gives information for the years 1980 to 1990, the 1990 edition for 1979 to 1989, *and so on.* Since the information on the current year is

¶ "Studies in the National Income and Expenditure of the United Kingdom" under the general editorship of Richard Stone. Of particular interest is Volume 6: "National Income, Expenditure and Output of the United Kingdom 1855-1965" (Feinstein,1972) liable to be highly provisional, subsequent editions of the *Blue Book* will generally give modified figures as more information is collected and processed. To minimize inaccuracy, it is advisable to take the latest series available. Thus the 1991 edition was used for the year 1980 onwards, the 1990 edition for 1979 only, *and so on*. A full list of the editions consulted is given in the References.

7.3.3: Input-Output Tables

In the UK, Input-output tables are presented as an adjunct to National Income Statistics and not as an integral part of it as for countries such as Denmark and the Netherlands. They are normally only produced for years when a full Census of Production is undertaken, although for other years the main Benchmark tables may be updated or estimated tables may be presented in summary form. The input-output tables available for the UK are presented in Table 7.3.1 below.

The first officially-produced tables were in 1954. Before that, tables were produced for 1935, by Tibor Barna (1952) and for 1948 by the Department of Applied Economics, University of Cambridge in association with the Board of Trade (Stewart, 1958). There are minor problems of compatibility for the tables earlier than 1963 with those from subsequent years. Adjustments to bring the early tables into line are outlined in Chapter 8.

The accuracy of the data will be variable and certain tables stem from updates from previous tables. For example, those for 1970-2 were produced as updates from the (benchmark) 1968 tables ¶ (Lynch, 1988):

> *... based upon rather mechanical updating methods, and published in the Business Monitor Series ...*

Despite these objections to the use of non-benchmark tables, the updated tables and summary tables will be used in the Case Study.

¶ The RAS iterative system was used to update the tables after 'fixing' a number of key figures such as energy usage and utilizing national income aggregates as control totals (Lynch, 1986a).

Table	Articulation	Type	Source
1935	36 x 36	Non-official	Barna (1952)
1948	8 x 8	Summary	*Blue Book* (1952)
1948	47 x 51	Semi-official	Stewart (1958)
1950	11 x 11	Summary	*Blue Book* (1956)
1954	46 x 46	Benchmark	*Studies in Official Statistics* No 8
1963	73 x 73	Benchmark	*Studies in Official Statistics* No 16
1968	91 x 91	Benchmark	*Studies in Official Statistics* No 22
1970	91 x 91	Update	*Business Monitor* PA1004
1971	60 x 60	Update	*Business Monitor* PA1004
1972	60 x 60	Update	*Business Monitor* PA1004
1973	35 x 35	Summary	*Economic Trends* (June 1978)
1974	103 x 103	Benchmark	*Business Monitor* PA1004
1979	100 x 100	Benchmark	*Business Monitor* PA1004
1984	102 x 102	Benchmark	*Input-Output Tables for the UK*
1985	102 x 102	Update	Diskette from CSO

Table 7.3.1: Input-Output Tables for the United Kingdom

7.3.4: Other data sources

The use of other sources will be avoided, as far as possible, to maintain consistency. Sources such as *Business Monitor* or *Housing and Construction Statistics* are occasionally employed. They will generally be used for to confirm or adjust or alternatively to disaggregate information from the *Blue Book* or other national income data series. Their use will be given in detail in Chapter 8 and in the Appendices.

7.3.5: Collection and publication of official statistics

Details of the methodology employed in the collection of data by the GSS and its subsequent publication are included in Appendix No 6. Information is also given on the derivation of the symmetrical input-output tables from the basic tables.

7.4: RELIABILITY AND ACCURACY OF DATA

7.4.1: Sources of errors

Errors within any of the official statistics as published may arise due to any one of a variety of reasons including the following:

a) Most published statistics will be derived from a partial census. Thus, the results are subject to sampling errors. If the sample is random, the error can, at least, be quantified using statistical theory.

b) Errors could also arise due to having an incomplete sampling frame. Thus *Housing and Construction Statistics* data does not include Northern Ireland, while *Business Monitor* makes no allowance for unregistered firms. The errors, in either case, can be estimated. However, the size of the 'black economy' in the UK – particularly within the construction sector — makes the latter a formidable task.

c) Equally, a changing sampling frame can cause problems. Thus, a change in the methods of sampling is liable to introduce discontinuity in time-series data. Also relevant are problems caused by changes in the SIC; thus, construction after the 1980 Revision no longer includes open cast coal mining and plant hire. It is not always possible to eliminate such factors, even if time-series are presented as discontinuities where such changed rules apply. The cumulative assessment of the capital invested in a particular industry will include investment in those factors no longer classified to the industry ¶.

d) If questionnaires are completed wrongly or not submitted the required information must be estimated. This process could lead to errors.

¶ In this case little damage is likely since the national accounts presents 11 year time series of national income and investment data. Thus changes will be effectively 'back dated' by 10 years. It is highly likely that the level of depreciation in construction plant will have eliminated the problem well within that time-frame.

e) Finally, errors may arise at the processing stage. The vast quantities of data generated by, say, a census of production could create problems of classification and analysis. However, the developments in computer technology might help to reduce this type of error.

7.4.2: Bias in statistics

Thus, there is potential for bias and inaccuracy. Clearly bias gives problems:

i) It can arise, with incomplete sampling frames, if the firms omitted from the register differ fundamentally from the firms included.

ii) Equally major changes in the SIC could introduce bias. This will be a particular problem if, say, the investment pattern of the heading(s) excluded was markedly different to the rest of the industry. Thus, plant hire is likely to be highly capital intensive and therefore its legacy will remain in construction for many years after the revisions to the SIC shifted it to 'hiring and leasing' within business services.

iii) The existence of bias will be difficult to assess in case of non-responses, particularly if those 'non-responders' were unevenly distributed across the sample set.

7.4.3: Imprecision in statistics

Samuel Johnson's maxim: *"Round numbers are always false"* (Huff, 1973) applies here. Rounding implies imprecision in the publication of the data. This leads to problems in presentation of data. The information may be rounded to, say, the nearest £1M, reflecting that it may be regarded as accurate to no more than £5M (or even £50M!). This gives the consequent problem of rounding errors and the infuriating situation where either a total does not equate to the sum of its components. Alternatively, an imprecise figure will be given a spurious aura of accuracy by presenting it to several decimal places. This presents a particular problem with the 1979 Input-output tables for the UK with all figures rounded to the nearest £1M, unlike the tables for 1974 and previously, which were presented to the nearest £0.1M.

The problem is clearly magnified for the transaction flow matrix of an input-output table. This applies because many of the elements are small, thus giving potential for very large rounding errors, in proportionate terms. In the 1979 tables over 60% of the intermediate transactions rounded to zero or £1M and serious rounding errors can arise.

These have to be adjusted for before computation can commence, otherwise severe problems may result in the subsequent matrix manipulation operations. Fortunately, a row subtotal is presented for the combined 'manufacturing' industries in the 1979 table. Since manufacturing accounts for 78 out of 100 sectors in the 1979 tables, the bulk of the rounding errors can be identified by correcting to match this subtotal.

Technology may have provided the ideal answer to this problem in that machine-readable data can be presented in rounded format while retaining 'accuracy'. Thus, the 1984 Input-output Tables for the UK are presented in the text to the nearest £1M but within the accompanying diskette they are stored to a precision of £0.1M ¶. It ensures reasonable correspondence between the individual elements and row and column totals without suggesting unrealistic precision for the figures.

7.4.4: Aggregation errors

Errors may also stem from problems of aggregation. In terms of the input-output matrices, this is not likely to present many problems for data availability in recent

¶ Only the limitations of space on the diskette limited the precision. The industry-by-industry tables obtained separately from the CSO were presented to much higher precision.

years given the high degree of articulation. It could cause problems if the implementation involved aggregation as for the 6-by-6 aggregation schema used. More serious problems could be created in terms of the capital matrix. These issues are specifically discussed in Chapter 9.

7.4.5: Accuracy

The reliability and accuracy of information on investment varies from industry to industry and will depend upon the method of assessment and the nature of the industry. In general, data for the industries within the public sector are likely to be more accurate than for private sector activities. The energy and manufacturing industries covered by the Census of Production are generally more reliable than 'service sector' industries such as banking and business services.

The CSO published letter grades to represent the reliability of data for particular categories by industry. Unfortunately no figures are quoted for the disaggregation of GNP and total profits by industry. It is expected that the GNP can be regarded as reliable to within plus or minus 3% (Grade A) while total profits will be within plus or minus 10% (grade B). Table 7.4.1 below illustrates this point.

However, no reliability figures are quoted for the input-output data. It may be assumed that the row and column totals are comparable to the estimates below for final demand and value added respectively. The inter-industry and intra-industry totals in the intermediate output matrix are likely to be less reliable particularly in the non-production/construction industries. Theoretically, input-output tables as a form of 'double entry' national accounting, ought be more reliable than other national income data since the row and column totals within the flow matrix must balance. Thus an error in a row figure should be detected by a discrepancy in the column and *vice versa*.

Value Added	Reliability Grade	Final Demand	Reliability Grade
Wages and Salaries	A	Consumption	A
Income of Self-employed	B	Government consumption	A
Company Profits	B	Fixed Capital Investment	B
Surplus from Public Enterprise	B	Stockbuilding	C
Rents	B	Exports and Imports	A
Property Income from Abroad	C	Factor Cost Adjustment	A
Gross National Income	A	Gross National Expenditure	A

Table 7.4.1: Reliability of Gross National Product data
Source: UK National Accounts: Sources and Methods (CSO,1985)

Key:	A	$\leq$	3%		
	B	>	3%	$\leq$	10%
	C	>	10%	$\leq$	20%
	D	>	20%		

However, the method of compilation, as outlined in Appendix No 7, and their lack of integration into the national accounts, suggests that aspects of the tables, notably output from the service industries, the reliability will be suspect. The particular case of inputs from business service into construction is discussed in Section 8.2.6.

The decision of the CSO to employ input-output techniques as part of the supply-side check on the accuracy of the national accounts (Lynch & Caplan, 1991) could help to improve this situation. Equally, the annual production of a composite use matrix from 1989 onwards (Hayes & Hughes, 1992) could lead to a closer integration of the input-output process in the national accounts. This might result in the UK following countries such as Denmark and Norway where input-output data is produced 'automatically' as part of the national income accounting process. Improvements in the accuracy of both national accounts and input-output data can be expected if this applies.

Industry	Reliability Grade	
	Investment	Capital stock
Agriculture	B	C
Fishing & Forestry	C	
Oil and Gas	B	C
Other Energy and Water Supply	A	D
Manufacturing	B	B
Construction	C	C
Distribution	B	D
Hotels	C	
Rail and Sea	B	D
Other Transport	C	
Communication	A	C
Banking	B	C
Business Services *etc.*	C	
Miscellaneous Services	C	D
Public Administration *etc.*	B	
Dwellings: Private	B	
Dwellings: Public	A	D
Transfer Costs of Real Estate	C	
Total	B	C

Table 7.4.2: Reliability of investment and capital data

Source: UK National Accounts: Sources and Methods (CSO, 1985)

The reliability figures for fixed capital investment and stock of fixed capital are given in Table 7.4.2 below. It should be noted that while the estimates of the latter are not employed in this Thesis. The reliability figures quoted may be expected to be in the same range as those derived in Chapter 8 for capital invested, using investment data and assumed notional rates of depreciation.

It should also be pointed out that the reliability figures for fixed capital investment falls when the estimate is presented in constant price terms. Thus construction drops from grade B to grade C for constant price investment ¶ (CSO, 1985).

¶ This may go some way to explain the large discrepancy between the reliability of investment data and that of the capital stock (which is derived from the former) as illustrated in Table 7.4.2 below.

Industry	Reliability Grade
Agriculture and Forestry	B
Extraction of Mineral Oil and Natural Gas	A
Other Energy and Water Supply	A
Manufacturing	B
Construction	C
Wholesale Distribution	B
Retail Distribution and Repair	B
Other Industries	C
Central Government	A
Overall	C

Table 7.4.3: Reliability of stockbuilding data

Source: UK National Accounts: Sources and Methods (CSO, 1985)

The reliability of estimates for stockbuilding, and therefore for working capital, is given in Table 7.4.3 above.

Two observations may be made regarding the errors in national income data. First there is the issue of errors in changes over time. The CSO (1985) suggests that:

> *In general the error in the change from year to year is likely to be less than might seem to be implied by the errors in the absolute values. This is because deviations between estimates and the facts are likely consist partly of a bias which is more or less constant from year to year and partly of a more random element.*

In addition, many of the errors attributed may not be connected with problems in estimating the total production or sales figures, but of its disaggregation to fit into the national account format.

Thus it is argued (CSO, 1985) that:

> *The proportionate error attached to the aggregates is likely to be less than the weighted mean of the proportionate errors attached to the components.*

The results, indicated in Table 7.4.1, appears to confirm the above observation. They rate an overall grade A although all the individual components, apart from 'income from employment', are graded B or C,

The implications of the reliability of the source data for the validity of the results of the Case Study and for the integrity of the theoretical model will be discussed in Chapter No 9. The recent changes in the methods of collection and publication of economic data by the GSS are also discussed in Chapter 9 in the context of the reliability of the statistics.

CHAPTER NO 8:

IMPLEMENTATION

He uses statistics as a drunken man uses lamp-posts — for support rather than illumination.

Andrew Lang

This Chapter outlines the implementation of the Case Study, this includes details of the four basic elements: the input-output tables, the capital inputs, ther profit outputs, and the calculation of the returns.

8.1: METHODOLOGY

8.1.1: Introduction

Having identified the sources of data in Chapter No 7, this Chapter will outline the implementation of the model and associated issues. This will include the key decisions on the computation and the presentation of information plus details of any assumptions made and adjustments made to the raw data.

The description of the Case Study should be read with the information given in Appendices Nos 1 to 8 and the associated Tables and Charts:

i) Appendix No 1 gives the information on the input-output tables used. This includes the raw data along with the adaptations and adjustments required. Examples of the computation of the Leontief inverse and the Eigenprices are also detailed.

ii) Appendix No 2 covers the 'input' data required for the model. It details the estimate of the 'initial' capital matrix for 1948 and the derivation of the capital matrices for subsequent years. It includes investment data from 1948 to 1990 inclusive, along with details of the approach to disaggregating the 'plant and machinery' investment figures. The implied capital price deflators used in the above process are included. The average age for the various types of capital used by each industrial group is derived.

iii) Appendix No 3 deals with the 'output' side of the model including the raw figures for value added and profits. It includes details of adjustments to the raw profit figures necessary to overcome the problem of the 'wage' element in payments to the self-employed.

iv) Appendix No 4 covers the calculation of the ratios. Direct return on capital invested is presented for each industrial group. It details the synthesis of the input and output figures using the Leontief inverse and the total computation of the (direct and indirect) returns on capital invested. The process is repeated after scaling prices using the 'eigenprice' vector.

v) Appendix No 5 covers a international comparison of eigenprices.

vi) Appendix No 6 gives background information on the methodology employed in compiling the statistical data used in the case study.

vii) Appendix No 7 lists the symbols used in the model.

8.1.2: Computation

The model is implemented using a spreadsheet program — Microsoft Excel — running on an Elonex PC386S. A spreadsheet was used for computations. There were several reasons for this, including ease of programming, and transparency of operations. It also had the advantage that the CSO now provides input-output data on a diskette in spreadsheet-readable format. Nearly all the required tasks can be dealt with using the mathematical functions and matrix operations provided within 'Excel'. The only function not provided was that required for the computation of eigenvalues and eigenvectors. A simple routine was available for this task.

All data are stored on linked spreadsheets to ensure consistency throughout. Therefore, all calculations can be carried-out within the spreadsheets. Graphical output from the spreadsheets is also provided on the summary result sheets.

Industry	SIC Group	Input-Output Table Headings
Agriculture, Forestry, and Fishing	0	1-2
Energy and Water Supply	1	3-8
Manufacturing	2-4	9-87
Construction	5	88
Distribution Transport and Communication	6-7	89-97
Banking, Insurance, and Other Services	8-9	98-102

Table 8.2.1: Aggregation of input-output tables

SIC Groups relate to the 1980 Classification (CSO, 1979)
Input-output Group headings are taken from the 1984 Input-output tables (CSO, 1988)

8.2: INPUT-OUTPUT TABLES

8.2.1: Degree of articulation

A bewildering range of format for input-output tables is used by the UK from 1935 onwards. This is outlined in Table 7.3.1. In all tables, construction is presented as a single industry. The other industrial groups, particularly manufacturing, are subjected to a variety of disaggregation. This leads to the first decision concerning the degree of articulation to be used in the analysis.

The main benchmark tables were published in 1954, 1963, 1968, 1974, 1979, and 1984. Even allowing for the changing categorization of 'industries', especially related to changes in the SIC in 1968 and 1980; it is possible to work with a reasonable degree of articulation¶. Other tables that do not stem from a full Census of Production and arise either from an update of a previous table or from estimated inter-industrial flows are presented in summary form and consequently offer less detail.

¶ It should be pointed out that much the additional detail in the Benchmark Tables is provided in terms of a very fine sub-division of the manufacturing industries which is fast declining in importance.

A broader classification is needed if long runs of data are required. A productivity time-series cannot be produced using only the main benchmark tables. The impact of the trade cycle and other economic fluctuations is liable to distort the situation. In any event, hardware and software limitations make an industry-by-industry classification larger than, say, [30 x 30] difficult, if not impossible. The complexity of the (memory hungry) array operations, in particular for the calculation of the 'eigenprices' identified in Chapter 5, makes it desirable to keep the input-output tableau as small as is feasible.

Accordingly, a [6 x 6] industry-by-industry aggregation of the tables is employed. This is desirable from a theoretical viewpoint and from the practical side. It is based on broad industrial groupings and the key trends will be clearly visible and not obscured by the volume of data. Table 8.2.1 above, presents the industry-by-industry categorization used. Summary tables are appropriate to study the broad trends. Features identified from the analysis in this Thesis may, subsequently, be fully explored using more detailed tables.

8.2.2: The treatment of imports

This presents a thorny problem for the compiler of an input-output table. Many economists would prefer imports to be split into two elements: complementary or noncompetitive imports¶ that are treated a part of the value added row vector, while competitive imports would be included within the inter-industry flows and taken as a negative element in the final demand column vector. Thus, exports would be presented net of competitive imports. Alternatively, all imports may be counted as value added or could left in a *hybrid* domestic production plus imports intermediate flow matrix. Here, they should be deducted from exports in the final demand vector to preserve the balance.

¶ Competitive imports are defined as goods for which home produced substitutes are available. Complementary imports are those which are not available on the home market. In the case of materials used by the construction industry, timber imports, for example, would fit into the latter group while reinforcement bars would fit into the former group.

Input	Input-Output Table Group Headings	Category
Imports of goods and services	104	Value Added
Sales by final demand	105	
Income from Employment	107	
Gross profits *etc.*	108	
Taxes on expenditure less subsidies	106	Residue

Table 8.2.2: Disaggregation of value added

Note: Input-output Group headings are taken from the 1984 Input-output tables (CSO, 1988)

Of the tables published for the UK, only the 1948 tables split imports into the two components. These were prepared by the University of Cambridge (Stewart, 1958). All subsequent tables treat imports as a row of the value added matrix. For the purposes of this study, the intermediate flow matrix is assumed to consist of domestic production only. Imports are included within value added.

8.2.3: Disaggregation of the value added vector

For the computation of 'eigenprices' the value added vector has to be presented in a disaggregated form. The Input-output tables for 1984 contain five elements instead of the more elaborate schema used in the main National Accounts. Thus the figure for profits, while given net of stock appreciation, includes all payments to the self-employed plus rent and interest payments and surplus from the public sector and any imputed charges for non-traded capital.

The profit total includes the residual error, the difference between the output and income based measures of national production. This is the most likely source of error. Similarly, indirect taxation is presented net of subsidies. Finally, imports and sales by final demand ¶ are included in value added instead of intermediate output.

¶ Sales by final demand comprised scrap materials and charges for government services for the 1963 tables. They do not correspond to the output of any industry and thus are treated by the CSO as primary inputs rather than intermediate production (Berman, 1970).

The calculation of eigenprices uses the same format as the input-output tables. However, indirect tax *less* subsidies is excluded value added and presented as a residual surplus. There are adjustments to the profits, because of the 'wage' element within the payments to the self-employed. The disaggregation of value added used in this analysis is presented in Table 8.2.2 above.

8.2.4: Industry verses Commodity tables

A choice is required between industry-by-industry and commodity-by-commodity tables. From the 1984 tables, the CSO standardized on the latter as opposed to the former. This follows the recommendation of the United Nations. Clearly as outlined by Lynch (1988) and Bon (1991), the commodity approach does have advantages over the industry approach. This is particularly marked for the case of productivity measurement since it is the productivity implicit in the construction of built assets as commodities instead of the performance of the construction industry that is being assessed. Thus any repair and maintenance work carried out by companies whose prime business is not construction could be 'captured' by a commodity analysis.

Unfortunately, the most tables are presented in industry-by-industry format. Commodity-by-commodity tables have been available for the benchmark tables since 1974, and could be derived for the 1954, 1963, and 1968 tables¶.

The process of derivation involves a transformation as outlined in Appendix No 6, using equations (A6.9) and (A6.10). This is necessary because, even with the make and the absorption matrices, it is not possible to compute the commodity tables without information on the assumptions regarding industry and commodity technology for the hybrid model employed.

¶ For the 1963 and 1968 tables, commodity-by-commodity matrices are presented in coefficient form. Subsequently, the 1974 and 1979 tables give both industry-by-industry and commodity-by-commodity matrices. In the case of 1984, the industry-by-industry flow matrix is only available on diskette direct from the CSO and is not included in the published tables.

$$\mathbf{E}_H = \mathbf{U\,H} \qquad (8.1)$$

$$\mathbf{A}_H = \mathbf{H\,U} \qquad (8.2)$$

where $\mathbf{E}_H$ = commodity by commodity coefficient matrix on assumptions of hybrid technology [N x N].
$\mathbf{A}_H$ = industry-by-industry coefficient matrix on assumptions of hybrid technology [N x N].
$\mathbf{U}$ = intermediate transactions part of absorption matrix [N x N].
$\mathbf{H}$ = hybrid technology matrix [N x N].

Of the above **U** is known but **H** unknown, thus $\mathbf{E}_H$ can be derived from $\mathbf{A}_H$ thus:

$$\mathbf{E}_H = \mathbf{U\,A}_H\mathbf{U}^{-1} = \mathbf{U\,H\,U\,U}^{-1} = \mathbf{U\,H} \qquad (8.3)$$

This would involve the inversion and multiplication of some very large matrices up to [44 x 44], and although feasible would be awkward. This task would be more difficult for the non-benchmark tables if no absorption matrix was provided.

Attempting to convert the summary and the other non-benchmark tables into commodity-by-commodity format is likely to be time-consuming. Similarly, adjustments are needed to the value added and investment totals. These are also presented by industry instead of by commodity.

It was reluctantly decided to use the industry-by-industry tables throughout in this Thesis. However, the commodity-by-commodity tables do have greater scope for future analysis. The decision will not have a significant impact on the results of the analysis. This stems from the correspondence between the Leontief inverse in each case. This reflects the dominance of the leading diagonal in the make matrix.

8.2.5: Industrial self-input

The treatment of industrial self-input, represented by the leading diagonal in the inter-industry flow matrix, has been the subject of *"a transatlantic controversy"* (Wolfson, 1978). Traditionally for the UK tables, industrial self-input is set at zero. US tables always included these flows. The sum involved is considerable for the UK construction industry. It represents the repair and maintenance of buildings owned by construction and, more significantly, the output of the subcontractors. In most tables, the figure for industrial self-input is available and presented in the flow matrix in brackets but not included in the row or column totals. From the 1984 tables onwards, the US procedure has been followed and self-input included.

Given the aggregation process employed in this exercise, the inclusion of industrial self-input is clearly preferable to its omission, particularly given the recent conversion of the CSO to the view that intra-industry flows represent *"meaningful economic transactions"* (CSO, 1988). The data is available for all years from 1963 onwards, although it has to be derived from the industry and commodity balances for the 1973 summary tables. In other tables, the self-input is derived from the figures on the leading diagonals of the make and the absorption matrices or is estimated. The estimates are based on the assumption of stability for the output coefficients to subsequent tables. Appendix No 1 gives full details of this.

8.2.6: Stability of the technical coefficients

The task of estimating a productivity time-series for the period 1948 to 1990 presents problems. There are only 13 years when an input-output table has been published (including summary tables and updates) out of a total of 43 years. In addition, the full 1948 tables proved incompatible in format and were not used. The earlier summary tables were used instead. For the intermediate years, between published tables, and for years after 1985, the computation relies on the stability of the technical coefficients.

Table	Years employed
1948	1948-49
1950	1950-51
1954	1952-58
1963	1959-65
1968	1966-69
1970	1970
1971	1971
1972	1972
1973	1973
1974	1974-76
1979	1977-81
1984	1982-84
1985	1985-90

Table 8.2.3: The employment of input-output tables in productivity measurement

Thus, the 1950 tables were used for 1948-52. Similarly, the 1954 tables were also used for 1953-8, *and so on*. The full list of the table used for each year is presented in Table 8.2.3, above.

Clearly, problems arise if marked instability is displayed within the input-output coefficients. This would take the form of a sharp discontinuity, particularly for the 'interface' years such as 1976 to 1977 and between 1981 and 1982. Previous studies for the USA (Bon, 1986), and also for the UK (Lowe, 1987f) (Ghionis, 1988) (Bon & Xu Bing, 1993), have shown a reasonable degree of stability in the coefficients within the supply-side Leontief inverse matrix (h_{ij}). The analysis in this Thesis confirmed this. For such 'interfaces', overlapping series were calculated. Thus, for the period 1964 to 1967, it was computed twice using first the 1963 tables and second the 1968 tables. Negligible differences were found between the two series, except the 1980 to 1983 period. Here, marked discrepancies emerged.

The key to this problem was identified by Bon (1991) as the result of changing assumptions, by the CSO, about the absorption of banking and business services by construction. A different approach was taken for the 1984 tables as opposed to 1979 and previous tables. The difference in the coefficients is far too great to be explained by the, admittedly, fast changing economic structure over the five years in question. Either the 1984 or, more likely, the 1979 (and previous) tables were wrong, something that the CSO comes near to acknowledging (Lynch, 1990):

> *The measurement of output of the service sector in gross terms and identification of its final destination between the intermediate or final destination, is one of the weaker areas of the national accounts. No firm information exists on the purchases by industry of such services As part of the process of compilation of input-output tables, the statistician is faced with conflicting evidence on supply and demand at the individual input-output group level. However, each group must be balanced to compile a set of tables consistent with a specified recent set of national accounts.*

Lynch then goes on to argue:

> *For 1984, it was decided that the purchases of business services by construction must be a very large amount, in order to reconcile the output and demand for both the service sector and the construction sector. This is the basis of the unusually high value shown in the 1984 tables. If a similar attitude had been taken in the compilation of the 1979 tables then a much higher level of purchases of business services by the construction sector would have resulted.*

Bon (1991) shows that from 1954 to 1979, in contrast to five other OECD countries (Japan, Finland, USA, Italy, and Ireland) direct inputs of services to construction in UK declined. This was followed by a major upward surge in 1984 to a level consistent with steady growth over the previous 30 years. This suggests that the series of direct service inputs to construction needs to be revised.

The 1984 tables appear more convincing than the 1979 tables. The latter give an output to construction from banking, finance, insurance, and business services of £120M. This is not credible since the above sector, apart from the core areas of banking, financial services, and insurance, *etc.*, includes SIC Activity No 837. This includes architecture, consulting engineering, quantity surveying, and technical services, In addition, the sector also covers legal services, property valuation, advertising, not to mention the hiring and leasing of plant!

The following observation by Lynch (1987) is particularly apt:

> *This [tables not reflecting reality] can only be avoided by conscientious exposure of provisional views to industry 'experts' to ensure that genuine data inconsistencies are not glossed over in the balancing process at the expense of representation of the true structure of the economy.*

Had that procedure been used for 1979, it is likely that the problem would have been identified by any economist familiar with the macro-structure of the construction industry ¶.

While some adjustment of the coefficients may be desirable, the tables were used 'as published' because of the problems inherent in amending them. Sections 9.2 and 9.3 cover the implication of any errors arising.

8.3: CALCULATION OF THE CAPITAL INPUT

8.3.1: Annual Investment

To apply the model outlined, all data on investment must be identified in a disaggregated form. Theoretically, this should present no problems either for an individual firm, using internal information, or from an industry, using published data. This presumes the consolidated from disaggregated figures of published data. However, in practice, it might not be available in the correct format. This is particularly apt for official national income statistics, given the way that such data are collected and published.

The accuracy of official sources is always open to question, as outlined in the last Chapter. It is, however, suitable for this type of illustrative analysis.

¶ To be fair, the gross output cited for construction in the 1979 tables of £20,920M is not too far adrift from the gross output cited in Housing and Construction Statistics (DoE, 1987) for 1979 of £19,397. This latter total excluded those small firms employing less than 5 in Northern Ireland which are not included in the DoE statistics. There remains a huge discrepancy between the data in the 1984 tables (£33,658M excluding industrial self-input) and those in Housing and Construction Statistics (£26,203M with Northern Ireland excluded).

While the data are subdivided by sector and by industry, they are not presented by asset type other than into three broad categories: land & buildings, plant & machinery, and vehicles. For the economy as a whole, the former is divided into dwellings and other buildings and works, while the latter are divided into road vehicles, railway rolling stock, ships, and aircraft.

For more information it is necessary to refer to the input-output tables. Recent editions include a detailed matrix of investment totals. For the 1984 tables it is set out by source and destination for 102 industries producing investment goods and 46 commodity groups using them. This has potential for producing a capital stock vector split into N [102] sectors. However, the data available from this source is limited since there are only figures given for recent years when a firmly based set of input-output tables have been published, *e.g.* 1968, 1974, 1979, and 1984.

If the above tables give similar results, it should be possible to use the coefficients as the basis for the disaggregation of the investment figures. This could be used to create a capital stock vector comprising up to 101 elements. Unfortunately, not only did the classification scheme change from one set of tables to another, but there also appears to have been several significant shifts in the pattern of investment over the period covered.

The above reflects the underlying structural changes in the economy, away from the traditional heavy industries towards the newer light industries and services. It requires, however, heroic assumptions on the stability of the elements in the investment matrix, to derive a fine classification of investment.

Some doubts have also been cast on the stability of the investment matrix. Klien (1989) suggested an econometric approach to analyzing investment. Further work to establish the above underlying trends contributing to the changing investment pattern should help to overcome this problem.

The data in the tables are only suitable for a broad classification of the capital stock vector. The scheme, in this Thesis, takes advantages of the breakdown provided in the national income data. Thus, *land and buildings* divide into 'dwellings' and 'real estate'; while vehicles divide into 'road vehicles', railway rolling stock', 'ships', and 'aerospace'. Finally, *plant and machinery* are split into four categories: 'metal goods & other equipment', 'agricultural, mining & construction plant', 'mechanical engineering', and 'electrical engineering'. Figure 8.3.1 below lists the ten-way classification.

The data required on capital investment are obtained, where possible, from national income statistics, using the *Blue Book*, supplemented, when necessary, from Feinstein (1972). Total investment data are broken-down into the ten-element vector as outlined above. The first six elements are disaggregated directly using the figures from the *Blue Book.* The last four elements, corresponding to the *plant & machinery* category, used investment figures from the *Blue Book,* disaggregated by reference to the relevant input-output tables. This relies on the 'total investment matrix' or the 'plant & machinery investment matrix' in the tables. Interpolation is used for intermediate years, between the published tables. For the years before 1968, the breakdown in the 1968 tables is taken; while for the years after 1985, the 1985 tables are used. Appendix 1 tabulates the percentages used in the investment disaggregation.

8.3.2: Transfer costs of real estate

The transfer cost of existing real estate is included in the investment figures published in the *Blue Book*. While this does not add to the aggregate stock of fixed capital, it is an outlay for those concerned. Accordingly, it is included within the *real estate* capital. The figures are not disaggregated within the *Blue Book*. Therefore, the industrial breakdown uses a breakdown *pro rata* to total investment 'sunk' in real estate.

	Category	Headings
1.	Real Estate	88 (part)
2.	Dwellings	88 (part)
3.	Road Vehicles	52
4.	Railway Rolling Stock	53 (part)
5.	Shipbuilding	53 (part)
6.	Aerospace	54
7.	Metal Goods, Other Equipment	31-33, 52-55 §
8.	Agricultural, Mining, and Construction Plant	34, 39-40
9.	Mechanical Engineering	35-38, 41-42, 56
10.	Electrical Engineering	43-51

Figure 8.3.1: Fixed capital investment vector breakdown

Note that headings are taken from the 1984 Input-output tables (CSO, 1988)
§ All headings not otherwise specified are included here

8.3.3: Working capital

Figures for stocks, consumables, and work-in-progress are taken from the *Blue Book*. Appendix 2 presents details of the breakdown of the 'other industries' category, as discussed in Appendix 7 Section A7.2.3.

8.3.4: Value of capital investment

Figures for the initial capital stock for the UK are taken from Feinstein (1972). This provides a breakdown into only four elements: land & buildings, dwellings, vehicles, and plant & machinery. Consequently, the latter two elements require disaggregation into four components each. This disaggregation is assumed having regard to the investment figures for each element. This should ensure the stability of the composition of the *capital stock* vector and growth in the capital asset base.

8.3.5: Price indices

The price indices employed are as used in the *Blue Book* to revalue capital investment from current prices to constant prices. They are tabulated in Appendix No 2. The indices are used to revalue the capital matrix from prices for year t, to those for year t+1.

8.3.6: Depreciation rates

The depreciation rates for each element in the capital stock vector are not directly comparable to those employed in the *Blue Book,* for the following reasons:

1. First, the depreciation allowed is purely nominal in that it makes no attempt to update the value of the physical assets but instead to assess a reasonable rate at which the investments sunk in such assets may be written-off. This will relate to asset life, and will be indirectly linked to physical/economic depreciation. Better correspondence may be found, however, with tax write-off provisions.

2. The capital stock is based on a **net** measure instead of the **gross** measure used in the national accounts; consequently, the nominal depreciation rates must be higher by a factor between one-half and two-thirds to take account of this.

3. The 'exponential decay' (with infinite life) approach is employed in this Thesis. Nominal depreciation rates are, thus, not equivalent to those appropriate for a straight-line model (with finite asset life). Comparison is very difficult here, although an idea may be obtained by reference to, the asset *half-life*, implicit with each approach. For example, a straight-line depreciation rate of 10% per annum would imply an asset life of ten years and consequently a '*half-life* of around five years.

The equivalent rate of 'exponential decay' to give an asset 'half-life' of five years is 13% per annum¶. Consequently, an increase in depreciation rates in the order of one-quarter to one-third will be implied, when using the 'exponential decay' model, as compared to the 'straight-line' approach.

Thus the depreciation rates assumed, for this exercise, will be considerably higher than those employed in the national accounts, largely for technical reasons, as opposed to dramatically differing assumptions over asset lifespan.

The current notional lifespan for capital assets used in the assessment of depreciation in the national accounts are not explicitly stated. However, the assumptions made by the CSO in the 1950s, as given in Table 8.2.3 below, are interesting for purposes of comparison.

Other studies of the fixed capital stock of the UK, include that of Redfearn (1955), Barna (1955, 1959), Dean (1964), Hibbert *et al* (1977). These could be used to check against the results obtained and the depreciation rates used.

8.4: VALUE ADDED AND PROFIT OUTPUTS

8.4.1: Direct profits

This information is from the *Blue Book*. The distribution of value added between labour and capital is also from the above. It is arguable that there ought to be adjustments, in certain cases, to deal with the impact of self employment. This follows from the fact that the 'profit' element within the value added figures in the *Blue Book* includes payments to the self-employed. At least part this, is a reward to labour as opposed to capital and therefore included within the wage element.

¶ The half-life of an item of capital is taken is taken as the time taken for its value to depreciate by 50%. Thus an item with a half-life of 5 years would depreciate at 12.95% per annum. This can be calculated thus:

$$0.5^{(1/5\ \text{years})} \cong 0.8705;\ \text{thus depreciation} = 1 - 0.8705 = 0.1295$$

	Category	Depreciation (PA)
1.	Real Estate	2%
2.	Dwellings	1%
3.	Road Vehicles	20%
4.	Railway Rolling Stock	15%
5.	Shipbuilding	10%
6.	Aerospace	15%
7.	Metal Goods, Other Equipment	5%
8.	Agricultural, Mining, and Construction Plant	15%
9.	Mechanical Engineering	8%
10.	Electrical Engineering	5%
11.	Working Capital	0%

Figure 8.2.2: Depreciation allowances

This is a particular problem for the construction industry in recent years since around half the operatives used by contractors appear now to be classified as self-employed. Thus, any assumption that the issue can be ignored since the self-employed will spread across all industries proportionately, is likely to be erroneous. Agriculture (small farmers and tenants) and construction (working proprietors and labour-only subcontractors) have disproportionate shares of the self-employed. Others such as energy and water supply have little or none.

Hard figures on the industrial distribution of the self-employed remain difficult to come by. The Department of Employment publish a distribution of the self-employed by industry (for Great Britain), on an occasional basis in *'Employment Gazette'* (Daly, 1991). The *Northern Ireland Abstract of Statistics* gives figures for the Province. The data for construction, consistent with Department of Employment figures, are given by the DoE in *Housing and Construction Statistics.* However doubts have been cast on the accuracy of the DoE figures by Leopold (1982) and Hillebrandt (1984). The issue concerns the major discrepancy between the DoE figures and Inland Revenue statistics.

Category	Life Assumption
Industrial Buildings	50 years
Commercial Buildings	75 years
Railway Buildings and Permanent Way	100 years
Dwellings	100 years
Road Vehicles	10 years
Tankers	25 years
Other Ships	30 years

Table 8.2.3: Life Assumptions for Capital Assets
Source: National Income Statistics: Sources and Methods (1956 edition)
Studies in Official Statistics No 3
(Based on tax depreciation rates)

Figures from *Employment Gazette* will be used in this Thesis for years after 1970. Before that, the distribution is estimated based on figures published in the *Annual Abstract of Statistics.*

This problem is of less significance for an overall input-output analysis than for a straight inter-industrial comparison. The synthesization provided by the Leontief inverse helps to 'dilute' the problem. However, the distortion to the time-series productivity data makes some adjustment imperative.

8.4.2: Adjustments to profit statistics

The approach takes the estimated numbers of self-employed in each industry. The average wages levels for employees in employment applicable to that industry are applied to the self-employed to reduce the profits by the notional 'wage' element. Earnings of the self-employed may be higher than for employees. However, it is reasonable to assume that such payments include an element of reward for entrepreneurship or capital investment as well as rewards for labour. The estimates of the distribution of the self-employed by industry and details of the calculations of the adjustments to the profit vector are presented in Appendix 3.

8.5: CALCULATION OF CAPITAL PRODUCTIVITY

8.5.1: Direct return on capital invested

This needs three calculations:

a) The raw return on capital invested is obtained for each industry by dividing the profit for a given year by the capital invested in that industry. See equation (3.20).

b) The composite rate of depreciation is calculated using equation (3.19) for each industry.

c) The discount rate is obtained for each industry using equation (3.21).

8.5.2: Total return on capital invested

Here the procedure is similar except that the direct profit is synthesized to total profit using equation (6.10). Direct capital usage is transformed into total capital *via* equation (6.8). The composite depreciation rate is identified using equation (6.16) and used to compute the discount rate for total return on capital invested.

8.5.3: Total return using eigenprices

The same approach is followed as above except that the capital input and profit output are scaled into eigenprices using equations (6.14) and equation (6.16) respectively. Total return on capital invested is then calculated. The former is scaled by the eigenprice associated with the industry producing the capital asset concerned and the latter scaled by the element of the eigenvector associated with profit.

8.6: RESULTS

8.6.1: Direct return on capital invested

The results for direct return are given in Chart 8.6.1. The results for the period 1977 to 1990 show that construction achieves a much higher return on capital invested than the other industrial groups. In addition, the gap is ever widening with others appearing to exhibit a degree of convergence. The figures cited for 1990 are provisional and more reliable figures will be obtained with later publication of the source data in the 1992 national accounts. It remains possible that the adjustment to the raw profit totals to take account of the wage element within the earnings of the self-employed may have been inadequate. The wage levels of self-employed may have been underestimated.

The wage element within payments to the self-employed estimated is essentially notional and, for that reason, the average wage rates for employees are used for the adjustments. The actual payments may be expected to contain an element of reward for entrepreneurship if not for capital. The distortions apparent for return on capital invested for construction in the late 1980s are probably due to high payments to self-employed subcontractors. Thus, the additional payments may be seen as 'economic rent' stemming from the exploitation of certain skill shortages during the construction 'boom' over this period. It is debatable whether such 'rent' should be attributed to wages or profit. Much of it remains in the latter for this analysis and therefore the high returns for capital productivity in construction. The onset of the recession, although outside the time-frame of this analysis, should tend to remove or at least mitigate such distortions.

The raw figures for profits in 1987 emphasize the size of the above problem. Construction, which has a turnover of around 25% of that of the manufacturing sector, had a 'profit' figure quoted of nearly half that registered for manufacturing. This is illustrated by Charts 8.6.1A-C giving the industry-by-industry shares of value added, capital invested and profits for 1990.

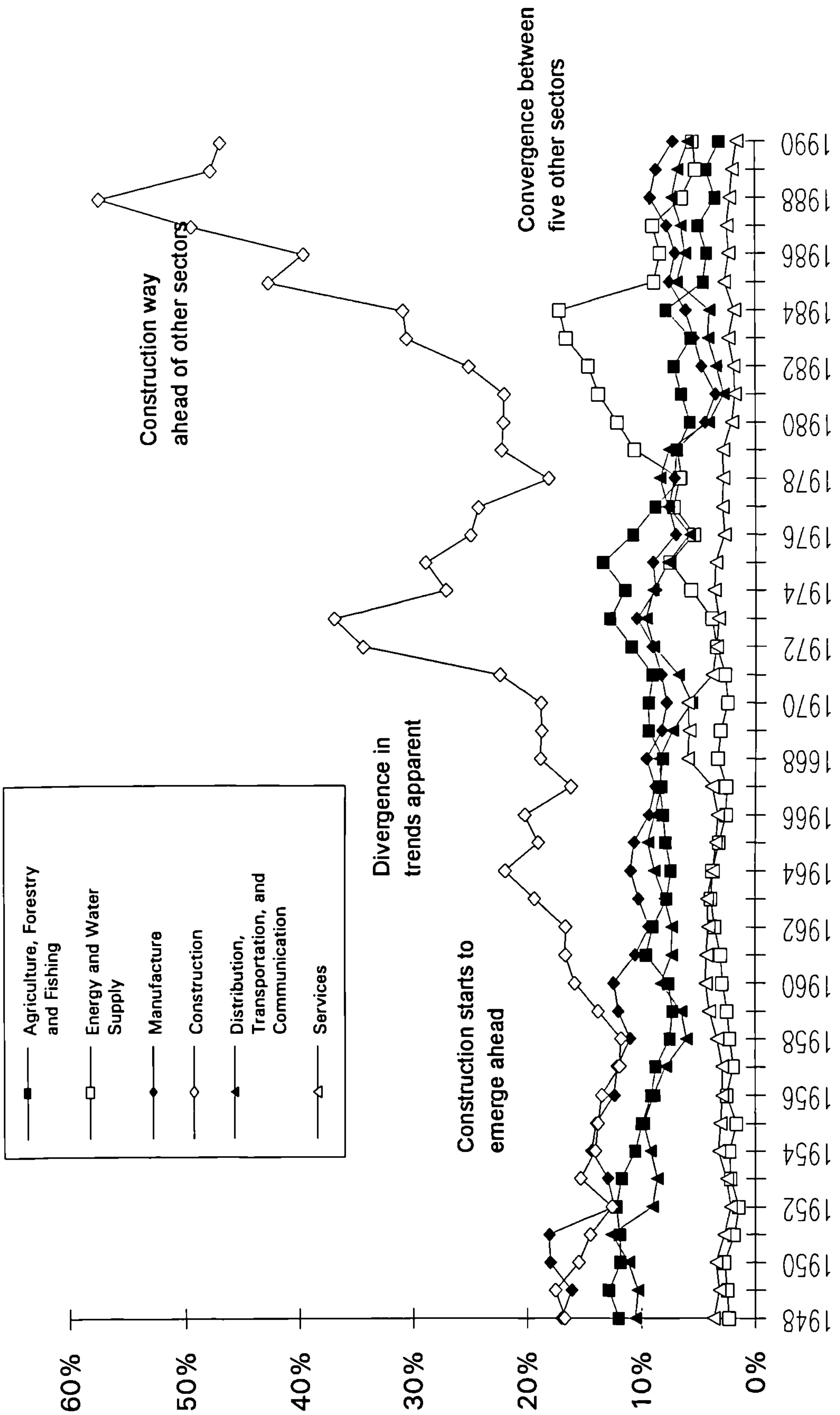


Chart No 8.6.1: Direct Returns on Capital Invested

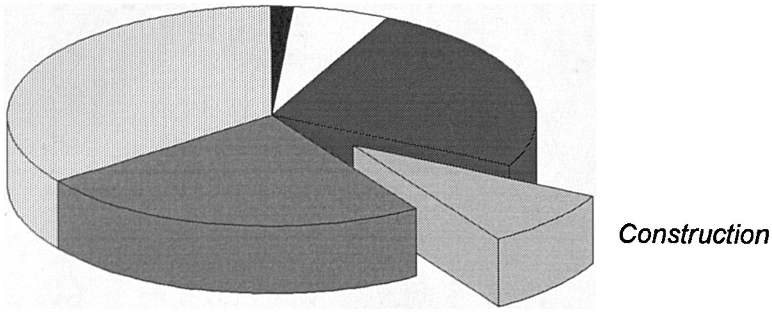


Chart 8.6.1A: Value Added by Industry 1990

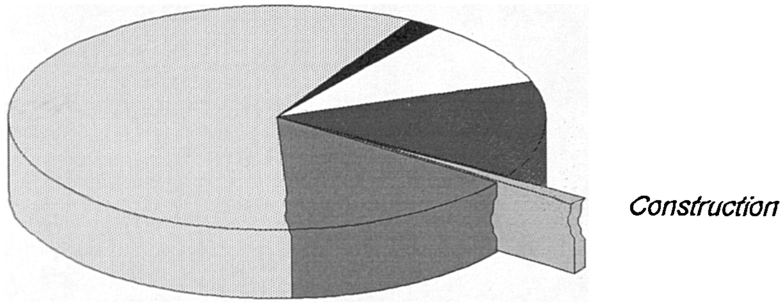


Chart 8.6.1B: Capital Invested by Industry 1990

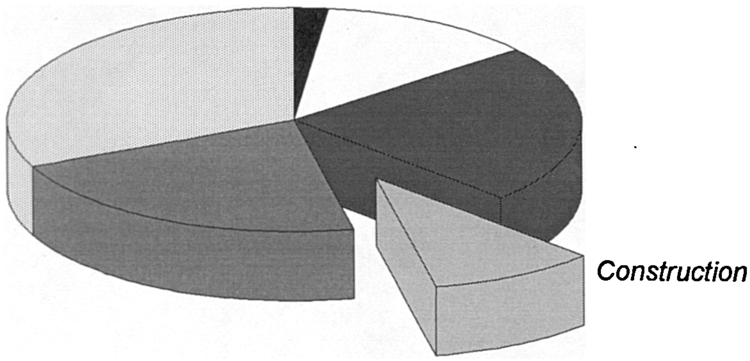


Chart 8.6.1C: Direct Profit by Industry 1990

Legend

- Agriculture, Forestry and Fishing
- Energy and Water Supply
- Manufacture
- Construction
- Distribution, Transportation, and Communication
- Services

Charts 8.6.1A-C:
Comparison of Value Added,
Capital Invested, and
Direct Profit Shares by Industry
for 1990

Thus, construction, ostensibly the most labour-intensive of industries has a very large proportion of value added apparently absorbed by capital. There is little that can be done to correct for this factor. The key point is to be aware of its existence.

The figures for 1948 to 1961 are comparatively free from the problem of self-employment, although they are likely to be less reliable than for the more recent years. They are largely presented for comparative purposes. The unreliability stems from the use of different industrial classifications and the lack of reliable data on working capital in the correct format. Also, in this earlier period the capital matrix has less time to settle down. The figures for 1962-76 are likely to be more reliable on the capital input side but less reliable on the profit output side given the emergence of labour-only subcontracting during this period.

8.6.2: Total return on capital invested

The outcome for total returns are given in Chart 8.6.2. and show a less distorted picture than the direct returns, although construction still dominates the picture and achieves the highest return on capital invested for most years of the period. This approach clearly 'dilutes' the residual distortion provided by the self-employed, although it is undoubtedly still present. Fuller details are given in Appendix 4 by Tables A4.2C. The figures for the earlier years again are less reliable for the reasons stated above. There is also a comparative weakness in the benchmark input-output tables published in the period before 1968.

Charts 8.6.2A-C illustrates the industry-by-industry share of gross output, total capital invested, and total profits.

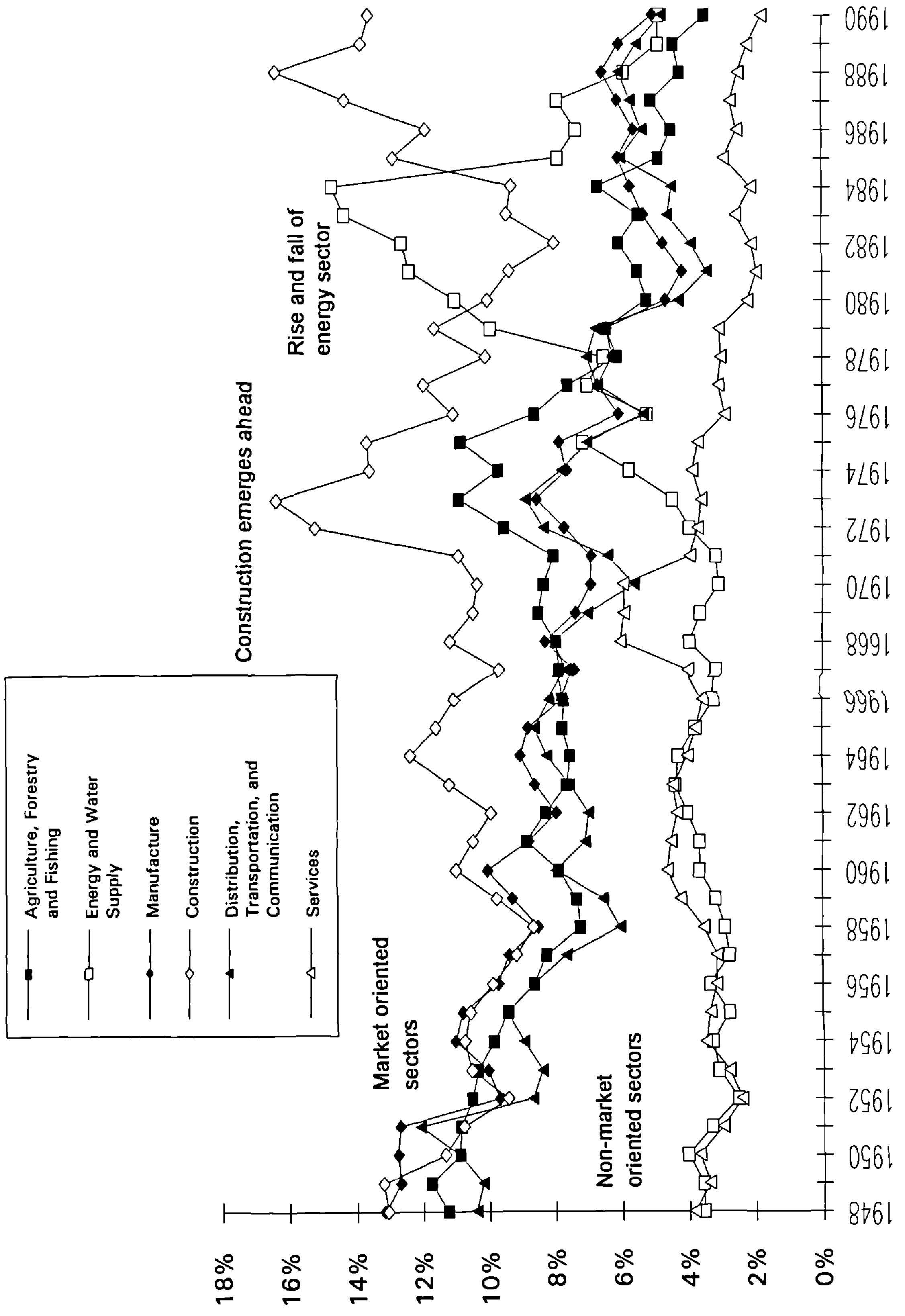


Chart No 8.6.2: Input-output Returns on Capital Invested

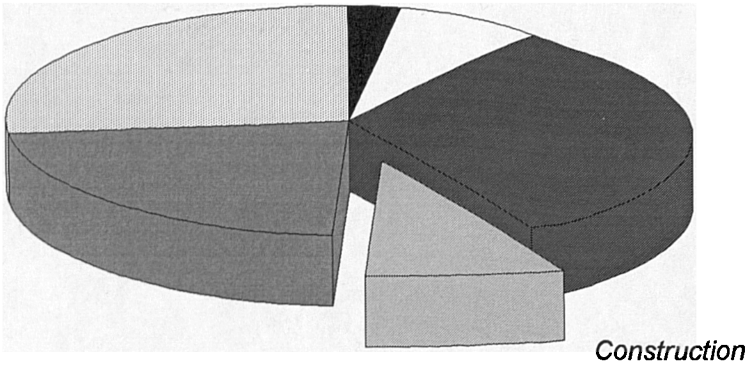


Chart 8.6.2A: Gross Output by Industry 1990

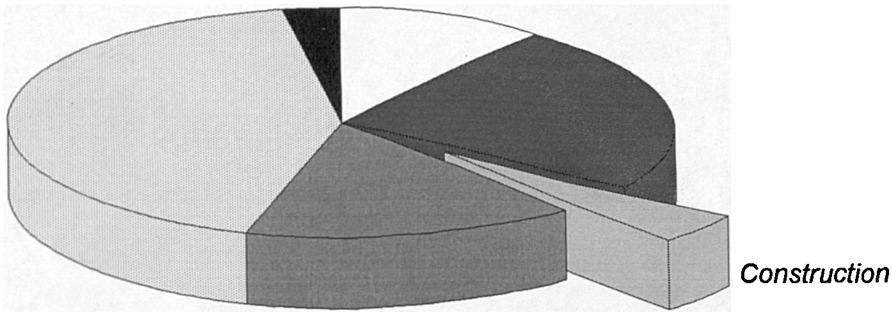


Chart 8.6.2B: Total Capital Invested by Industry 1990

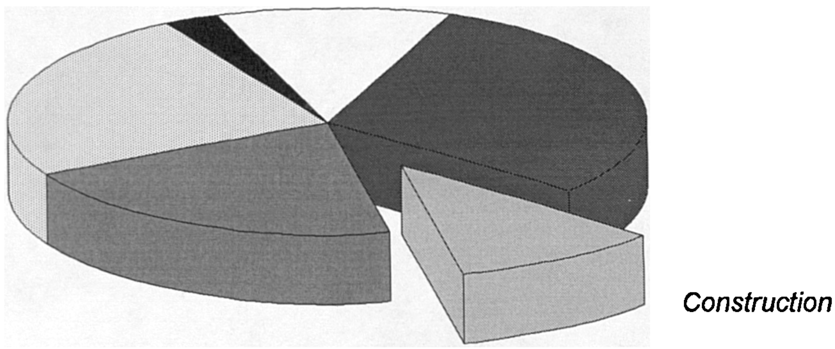
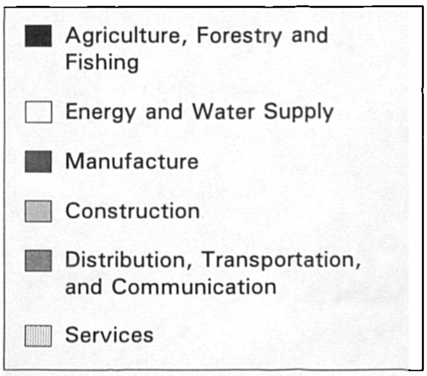


Chart 8.6.2C: Total Profits by Industry 1990

Legend



Charts 8.6.2A-C:
Comparison of Gross Output, Total Capital Invested, and Total Profits by Industry for 1990

8.6.3: Total return using eigenprices

The scaling of input and output elements into eigenprices has little impact on the results as illustrated in Appendix 4 by Tables A4.2A-C and Charts A4.2.3A-C. This was to be expected and is in line with the results obtained in Seton's (1985) study. This suggested a low level of 'price deviance' between individual industries in the UK, a marked contrast to many other countries. This is discussed below and a limited international comparison of eigenprices is presented in Appendix No 5.

8.6.4: Conclusions

The reliability of the results obtained warrants more discussion. The problems associated with the raw data and the adaptions needed to make them usable over a 40-year six-industry time-series raise some interesting issues. This will be covered in the next Chapter.

While detailed analysis of the results is beyond the scope of this Thesis, two issues stand out and require some explanation if the model is to retain credibility.

1. There is a marked divergence between construction productivity and other sectors of the economy. This warrants more discussion.

2. There is remarkable similarity between eigenprices and market prices for the UK. Seton's (1985) original figures show that this does not apply to all economies. This is illustrated by an international comparison of eigenprices in selected countries in Appendix No 5.

The key conclusions on the above issues and the implications for the efficacy and validity of the model are discussed in Chapter No 10 in the context of its robustness and reliability.

CHAPTER NO 9:

RELIABILITY OF RESULTS

It ain't so much the things we don't know that get us in trouble. It's the things we know that ain't so.

Artemus Ward

This Chapter analyzes the reliability of the results obtained and the likely sources of error with particular attention to the accuracy of the Official Statistics employed in the Case Study.

9.1: ERRORS IN MATHEMATICAL MODELS

9.1.1: Numerical analysis

Numerical analysis is a branch of mathematics that represents the traditional approach to dealing with reliability of numerical calculations. Any attempt to represent real problems by mathematical models is liable to be prone to problems of errors creeping into the solution process. The process can be illustrated as

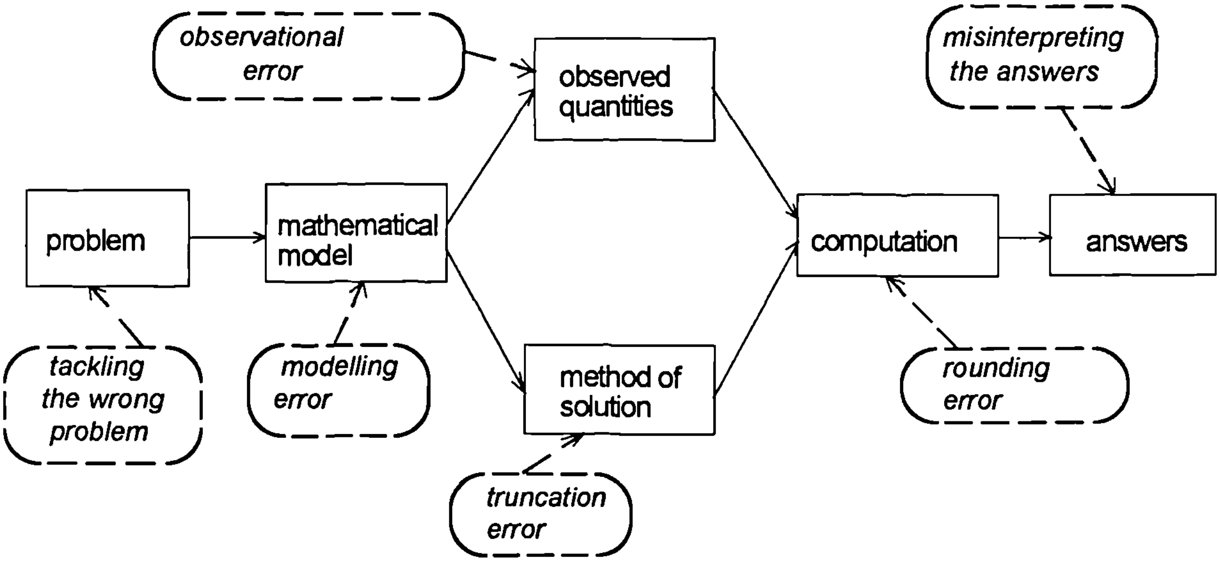


Figure 9.1.1: The numerical solution of real problems
Source: Open University M371 Course Team (1988)

above. Leaving aside the issue of tackling the wrong problem and that of misinterpretation of results, the following represent the main types of unavoidable error.

9.1.2: Modelling errors

The formulation of any problem in mathematical terms must be a simplification to make the model manageable. The input-output model depends on assumptions of linear relationships, constant returns to scale, no joint production, *etc.* These can all contribute to this kind of error.

9.1.3: Observational error

Errors implicit in counting and measuring data values can cause problems as outlined in the discussion on published statistical information and its reliability in Chapter 7.

9.1.4: Truncation errors

This will arise in situations where, say, an iterative process is terminated after a finite number of steps. Any process that takes an infinite number of iterations to converge will have to be ended somewhere. Errors are created by such approximations.

Errors stemming from aggregation of arrays either for computational convenience or lack of articulation in the raw data could also be included here, as alluded to in Chapter 8.

9.1.5: Rounding error

Rounding errors can cause major problems with numerical calculations carried out by calculator or computer. This is a fundamental problem of the difficulty of dealing with certain fractions in floating point binary numbers. Fractions such as 'one-half' or 'one-quarter' causes no problem but 'one-third' or 'one-sixth' present difficulties. A computer stores 'one third' as 0.3333...3 to a fixed number of points, thus either the last decimal point must be rounded up or truncated.

The internal storage capacity of the computer determines the precision with which such numbers are held. Usually, any rounding or truncation error will have no real impact on the outcome. If either ill-conditioning or induced instability is present in the model, problems can arise. Paragraph 9.2.2 covers these two sources of error. The greater internal storage capacity of modern hardware will tend to reduce this problem.

9.1.6: Absolute and relative errors

Errors can be expressed in absolute or relative terms. The absolute error is the modulus of the deviation (δx) of the computed value (x) from the actual value (x):

$$|\delta x| \quad = \quad x \; - \; \mathrm{x} \qquad (9.1)$$

where $|\delta x|$ = absolute error
x = computed solution
x = actual solution

Usually, the true answer is not known but if known to within a certain interval; the absolute error bound can be defined as the difference between the upper and lower estimate. An absolute error bound must satisfy the inequality:

$$|\delta x| \quad \leq \quad \varepsilon_x \qquad (9.2)$$

where ε_x = absolute error bound

For a rounding error, if the exact value is rounded to n decimal places then the absolute error bound (ε_x) for x is equal to $5 \times 10^{-(n+1)}$.

Frequently, the relative error will be of more significance than the absolute error. Thus an error of £1M will be less critical for a value of £100M than for one of £2M. The relative error bound is also defined by an inequality:

$$r_x \quad = \quad |\delta x / x| \qquad (9.3)$$

$$r_x \quad \leq \quad \rho_x \qquad (9.4)$$

where r_x = relative error
ρ_x = relative error bound

9.2: ERRORS IN THIS MODEL

9.2.1: Validity of results

The validity and reliability of the results will depend upon several factors, including the following:

a) The accuracy of the computations carried out. Here there is some scope for error in the matrix operations. Examples of this include, matrix inversion used in arriving at the Leontief inverse and matrix multiplication in the synthesization of direct inputs and output to total inputs and outputs. The calculation of the eigenvalues and eigenvectors also involves very heavy computation. Other calculations are less prone to error.

b) The accuracy of the data for intermediate and final transactions, included within the input-output tables.

c) The accuracy of the derived capital matrix used. This is dependent upon the quality of data on initial capital valuation and subsequent investment. It will also be affected by the decisions taken on the disaggregation of the initial capital valuation and the subsequent investment figures into capital type and industrial groups.

d) The accuracy of published data on profits made and its disaggregation into industrial groups. The distortion in official statistics *via* the inclusion of payments to the self-employed is critical here.

The above factors are considered, in-turn, to evaluate the reliability of the results and to suggest further work to improve the model.

9.2.2: Accuracy in computations

Two possible sources for problems can arise in respect of numerical solutions to mathematical problems, ill-conditioning and induced instability ¶.

a) **Ill-conditioning** arises due to extreme sensitivity of the output to small changes in the input. Thus a marginal change made in, say, the capital direct input vector could have dramatic consequences for the total capital usage vector. This implies ill-conditioning in the matrix multiplication process involving the Leontief inverse. Equally, it would be implied if small changes in the direct output technical coefficients lead to large changes in the Leontief inverse. Thus, it is not the method of computation that causes the problem, it also would apply with exact arithmetic. Consequently, small errors can play havoc with the results.

b) **Induced instability**, by contrast, does stem from the method of computation. Thus dramatically different results from those obtained by exact arithmetic, will follow if the method of calculation introduces induced instability into the model. The result is essentially the same with small rounding errors having the potential to cause monumental errors.

The computation of the inverse Leontief matrix and subsequent matrix operations is not usually ill-conditioned due to the nature of the model. No doubt, it would be possible to concoct an (artificial) ill-conditioned model if necessary. Induced instability arises if the iterative schema chosen, here using the internal procedures within the 'Excel' spreadsheet, causes rounding or truncation errors to be magnified.

¶ In essence, ill-conditioning relates to the problem, whereas induced instability related to the method chosen to solve the problem. Thus, problems of induced instability can often be overcome by a different approach. Ill-conditioning cannot be so easily dealt with and will apply even if exact arithmetic is used.

No evidence of induced instability emerged. The model can, in any event, be checked by pre-multiplying the Leontief inverse by the value added vector and checking if the total input figures obtained match the original. This procedure was carried out in each case. The only problems arose when the 'rounding errors' in the published data, outlined in Appendix No 6, produced major discrepancies between the total input vector and the total output vector. To eliminate this problem, the former was taken as the transpose of the latter instead of the column sums.

For the calculation of the eigenvalues and eigenvectors, the computation can sometimes be ill-conditioned. This is unlikely, for the *dominant* eigenvalue and associated eigenvectors required in the model. The iterative schema outlined in Chapter 6 appeared free from induced instability. The model is again self-checking, since incorrect results would show up in inconsistencies in the input-output schema scaled into eigenprices.

Thus it is reasonable to assume, that no problems with induced instability are likely to arise if reasonable precautions are taken and the results are checked for consistency whenever practicable.

9.2.3: Accuracy of the input-output tables

Section 8.2.6 discusses the precision of the figures presented in published input-output tables in some detail. Two factors must be present for there to be a risk of serious error stemming from inaccuracy in the intermediate and/or the final transactions:

i) There must be a significant error in the technical coefficients **and**

ii) the absolute amount of the transaction must itself be significant.

Thus, a significant (proportional) error in a technical coefficient will not have much impact on the outcome if the value of the technical coefficient is very small.

From the discussion in Chapter 8, it would appear that the most reliable results will be found for those industries covered by the Annual Census of Production. Thus, the energy and manufacturing sectors, and to a lesser extent construction, will probably be reliable in respect of intermediate *outputs*. In the case of agriculture, transportation/distribution, and the services industries, the *outputs* will be less reliable. The outputs from agriculture, apart from that to manufacturing and to itself, are very small. Equally, all intermediate outputs from construction, apart from self-input are totally insignificant. Thus, these elements can be eliminated as a serious source of error even with very high relative errors. This leaves the intermediate output from the transportation and trade industrial group plus services as major candidates for error.

The likely sources of error in the (supply-side or demand-side) technical matrix are illustrated in Table 9.1.1. The elements having the potential for significant error represented by a plus (+) while those deemed unlikely to cause problems are represented by a zero (0). It would have been useful if the above information was used to construct an inverse Leontief matrix based on qualitative principles, however, this is not possible.

The Leontief inverse $[\mathbf{I} - \mathbf{A}]^{-1}$ is equal to the summation: $\mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + ... + \mathbf{A}^n$ as n tends to infinity as outlined in equation (4.19). In the above case, the computation will result in errors appearing in all elements. However, it is probable that the more significant errors will appear as in Table 9.1.1 below. It should be noted that the Leontief inverse has a dominant leading diagonal, and thus high relative errors on the leading diagonal will have a disproportionate impact on the outcome. Despite that, the same absolute error anywhere in the matrix will produce errors of a similar scale.

	Agriculture, Forestry and Fishing	Energy and Water Supply	Manufacturing	Construction	Distribution, Transportation, etc.	Services
Agriculture, Forestry and Fishing	+	0	+	0	0	0
Energy and Water Supply	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Construction	0	0	0	+	0	0
Distribution, Transportation, etc.	+	+	+	+	+	+
Services	+	+	+	+	+	+

Table 9.1.1: Likely sources of error in input-output tables

Key	+	significant error likely
	0	significant error unlikely

It is most likely that absolute errors will be present in the inter-industry flow matrix and that these will be transformed into equivalent relative errors in the Leontief inverse. However it is possible that the relative errors (although not the absolute errors) will be smaller in the leading diagonal because of the nature of the Leontief inverse. The power series $[\mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + ... + \mathbf{A}^n]$ as shown in equation (4.19) gives a hint as to the reason for this. The leading diagonal is a product of a summation of 1 (the entry in **I**, that ought to be error free!) and components from $\mathbf{A}$, $\mathbf{A}^2$, $\mathbf{A}^3$, ...+ $\mathbf{A}^n$. (that will be subject to errors). Other elements, off the leading diagonal, will be smaller and therefore the error prone components are liable to be of more significance for relative errors.

The nature of input-output statistics, as outlined in Section 7.4.5 above, makes them less vulnerable to error than for other national income statistics.

9.2.4: Accuracy of the derived capital matrix

There is probably greater scope for error in this part of the model than for any other. This can take the following forms:

a) Errors in both the initial fixed capital stock and its disaggregation into a [6 x 10] matrix could present problems. The figures taken from Feinstein (1972) are presented for 1948 disaggregated into industries and into types of capital – dwellings, real estate, plant and machinery, road vehicles, *etc.*, – but no two-way disaggregation is provided. This must be estimated. There is some scope for error in this process. However, the figures from 1968 onwards should be more reliable, since any error will have been 'depreciating' for twenty years.

b) Errors may exist in the figures quoted for investment in fixed capital assets and their disaggregation. The accuracy of investment figures are reasonable, as outlined in Chapter 7. The figures for their breakdown are likely to be reliable from 1968 onwards since investment matrices are given in the benchmark input-output tables.

c) Inaccuracies may exist in the indices used to update the capital matrix for the impact of inflation each year.

d) There are errors stemming from the depreciation rates selected for each capital asset type.

e) Finally there will be errors in the estimate of the working capital vector, particularly for years before 1968.

The net impact of all the above is that the accuracy of the capital matrix will be dubious before 1968, but better for recent years with an approximate grade C.

9.2.5: Accuracy of the profit vector

The figures are expected to be reliable, apart from the problem of disentangling the payments to the self-employed, outlined in Section 8.4. As with the capital matrix above, the aggregate total is likely to be more accurate than the individual components.

9.2.6: Aggregation errors

This can take two forms:

a) Errors caused by aggregation of industries within the input-output flow matrix. Thus, in the derivation of the symmetrical input-output tables, there is potential for error. This could take the form of the 'loss' of secondary production from the make matrix, since this usually tends to arise in commodities 'associated' with the primary product. This will blur the distinction between industry and commodity-based approaches. This will not arise in this Case Study since despite the example in Appendix No 1. The [6 x 6] industry-by-industry tables used were aggregated from the full [102 x 102] industry-by-industry tables. They were not derived from aggregated make and absorption matrices. The impact of aggregation errors is discussed in Miller & Blair (1985).

b) Errors caused by aggregation in the capital matrix are potentially more troublesome. This has some parallels to point a) above, since the capital verctor is disaggregated into an industry-by-capital asset matrix. In the theoretical model, objections to the use of capital productivity are, to some extent, overcome by disaggregation of capital into asset types. This will be undermined, if too few asset types are employed. The disaggregation, into [11] asset types, while not ideal, is the best that could be achieved in the circumstances. The use of a limited number of industries [6] can also cause problems.

The main problems identified in the Case Study stem from the inclusion of 'public administration' and 'ownership of dwellings' within the services industrial group. While the banking, finance, and professional services part of this group has a substantial input into construction and production industries, at least in the 1984 tables, public administration *etc.* does not.

This produces a distortion, with some substantial holdings of capital assets by public administration and in dwellings, being set against the main industries due to the synthesization effects of the Leontief Inverse. There is little that can be done about this for the type of long-run analysis in the Case Study since it is not possible to unscramble the output variables although it is possible for the inputs.

9.3: IMPACT ON COMPUTATIONS

9.3.1: Initial conclusions

If we follow through the implications of the above on the computations, then the initial conclusions are very disturbing indeed. The Leontief matrix with (unstated) accuracy in its individual elements is pre-multiplied by the capital matrix. At best the capital matrix will have reliability of Grade C. This implies a precision of plus or minus 20%. This corresponds to a relative error bound of around 40%. It is likely to be widened, if anything, in the synthesization process due to errors in the Leontief inverse.

The profit vector, with overall accuracy of Grade B, and therefore a relative error bound of 20%, is also synthesized and the outcome used to identify profitability by use of the synthesized capital matrix. An error bound of 60% or more could easily be conceived for the outcome.

9.3.2: Mitigating factors

However, several factors raised by the CSO, as discussed in Appendix No 6, should contribute to make the actual reliability somewhat better than the gloomy prognostications above:

a) First, there is the point that the bias in the data will be fairly constant over time. Thus for the time-series analysis, its reliability will be better than the raw figures suggest. This will not apply, however, to inter-industrial or international comparisons.

b) Second, there is the issue of errors generated in the disaggregation process. If, say, capital is misplaced from one industry to another, the impact of the synthesization process will tend to correct for this error. If the total capital usage across all industries in question is accurate, then the overall result should also be accurate.

c) Third, there is a strong possibility that errors in the profit vector and errors in the investment matrix will be correlated. Thus, if there is significant under-reporting of construction profits, it is likely that the investment figures will similarly be recorded on the low side. Thus, two errors could be partially self-correcting. This will certainly be the case for errors stemming from an inadequate sampling frame.

d) Fourth, it should also be pointed since both the input (capital) and output (profit) vectors are synthesized using the same Leontief inverse matrix. The impact of errors in the inverse will be, to a large extent, cancelled by this process.

9.3.3: Conclusions on accuracy of results

The implication of the above on the reliability of the results, uncomfortable though it comes over, is probably little worse than for most other research into applied macroeconomics. It is likely to be a good deal better than work in applied microeconomics based on survey or questionnaire data. Here the problems are, at least, explicitly stated and not than glossed over. This is clearly going to be unpalatable for many economists.

Like it or not, the official statistics are the best that are available for the UK, and may be significantly better than is available for other countries. Either they must be used or else applied macroeconomic research cannot continue.

The problems experienced, illustrate the need for accurate, reliable, and up-to-date official economic statistics. The Government Statistical Service is operating under constraints, in terms of resources and the extent that businesses are prepared to co-operate by filling in questionnaires and surveys. Such enquiries may be statutory; but these are limited in number. Alternatively they may be voluntary and require the compliance of the companies to fill in the forms.

Some benefit needs to be shown to companies to encourage their enthusiastic participation in the exercise. Moser (1980) outlined the key CSO objectives that focused the collection and publication of, if anything, less information but with more concentration on quality.

Some important reviews into data collection were carried out by Raynor in 1979-80 (Hoinville & Smith, 1982). The outcome has been a loss of quality of results since some surveys have been discontinued while others were reduced in frequency and/or had their sample sizes cut. This appeared to be aimed at cost reduction and at reducing the 'form filling' for businesses.

Recently the Government has taken steps to improve the quality of economic statistics in the U.K. (Daniel, 1991). This involved the commissioning of a review of economic statistics – the 'Pickford Report' ¶ – and some initiatives by the former Chancellor, John Major, to improve the quality of the less reliable economic data. This has involved a new statutory enquiry on production stocks, wholesale stocks and fixed capital investment. Also, more information is now collected on the turnover of certain service industries. The improvements stemming from the above initiatives should soon work through to the published data.

Also, improvements in accuracy of the U.K. National Accounts are promised by use of 'supply-side' data using information obtained from the benchmark input-output tables to check the weaker aspects of published information. The voluntary sampling procedure used for assessment of capital investment could be so checked. It is envisaged that a supply-side model is used to replace such unreliable data (Lynch & Caplan, 1991).

There are, of course, much better arguments for the availability of good quality economic statistics, than that they should exist for the benefit of academic study. Paramount, in this list are the needs of government for data to enable effective economic management. In addition, there are the needs of the electorate for accurate and independent information on economic performance. This will help ensure the survival of democracy, given the extent of concentration on the key economic indicators in modern elections.

¶ "Government Economic Statistics, A Scrutiny Report", April 1989, HMSO

CHAPTER NO 10:

ANALYSIS, CONCLUSIONS,

AND FURTHER WORK

Life is the art of drawing sufficient conclusions
from insufficient premises

Samuel Butler

This Chapter attempts to explain the results obtained in Chapter No 8 in terms of the economic structure of the construction sector. The implications of the Case Study results on the model are discussed. Recommendations for further study are also included.

10.1: THE CASE STUDY RESULTS

10.1.1: Capital productivity in the UK

The thrust of this work is not to analyze trends in productivity for the UK construction industry but to develop and test an approach to measure construction productivity. Therefore, it is inappropriate to dwell to long on the results of the Case Study, except as it impinges on the efficacy of the model. However, given the remarkable results obtained for capital productivity in the UK, some analysis is necessary to ensure the credibility of the model. Despite the large relative error bounds on the input data used and the caveats expressed on this issue, the results do show that construction achieves very high capital productivity statistics indeed and this warrents some discussion. In addition the marked similarity of market prices to the eigenprices obtained in tha analysis also requires some attention.

10.1.2: Comparison with other studies

The performance of the UK construction industry in terms of capital productivity proved to be very impressive over the period of study. In some respects the results are dramatically better than expected. Indeed, the 'direct capital productivity' figures proved to be much better than those obtained in a pilot study carried out earlier (Lowe, 1988) which employed a more traditional approach to the measurement of capital productivity.

It should also be pointed out that the earlier analysis employed a different approach to the 'self-employment' problem in that a fixed distributional parameter for labour (α) was imposed on the model. Also, Census of Production data, taken from *Business Monitor* (Lowe, 1990a), was used as the source for investment data instead of the national income data employed in this Thesis. A marked discrepancy was detected between the two data series. Appendix 2 details the computation and the data sources used. No other recent studies of construction productivity in the UK were available for further comparison.

10.1.3: Overview of the Case Study results

Overall, the results appear credible apart from the specific instances referred to in Chapters 7 and 8, and evaluated in Chapter 9. This would include such issues as the overstatement of profit figures, because of the inclusion of the earnings of the self-employed. In addition, there are the discrepancies in the direct and indirect inputs to construction from the business services sector over the years. These effects were filtered out where possible.

The results also appear to follow the same broad pattern as that identified in the earlier study (Lowe, 1988). The productivity statistics for construction (however measured) appear to increase during periods of economic growth and to decline during a slump. Thus, clear peaks can be identified in 1973 and 1989. Equally, sharp downturns are identified in 1974-5, 1980-1, and 1989-90. This does not contradict conventional economic thinking. Chart 10.1.1 presents graphs of the three alternative measures: Direct return on capital invested, input-output (total) return on capital invested, and input-output returns scaled into eigenprices.

Chart 10.1.2 illustrates these productivity trends by juxtaposing the direct and input-output productivity figures for construction over the period 1948-90 against key economic and political events. In terms of the inter-industry analysis, the trends apparent for construction are generally in line with those of the other industrial sectors. The one exception to this is the energy and water supply industry. Its performance is more likely to be influenced by factors such as world oil prices and coal prices than by domestic economic circumstances. Construction remains, consistently, as the highest performer, in capital productivity terms, for both direct and input-output measures for the past thirty years. It was temporarily displaced, in the mid-1980s by energy and water supply, for the input-output figures.

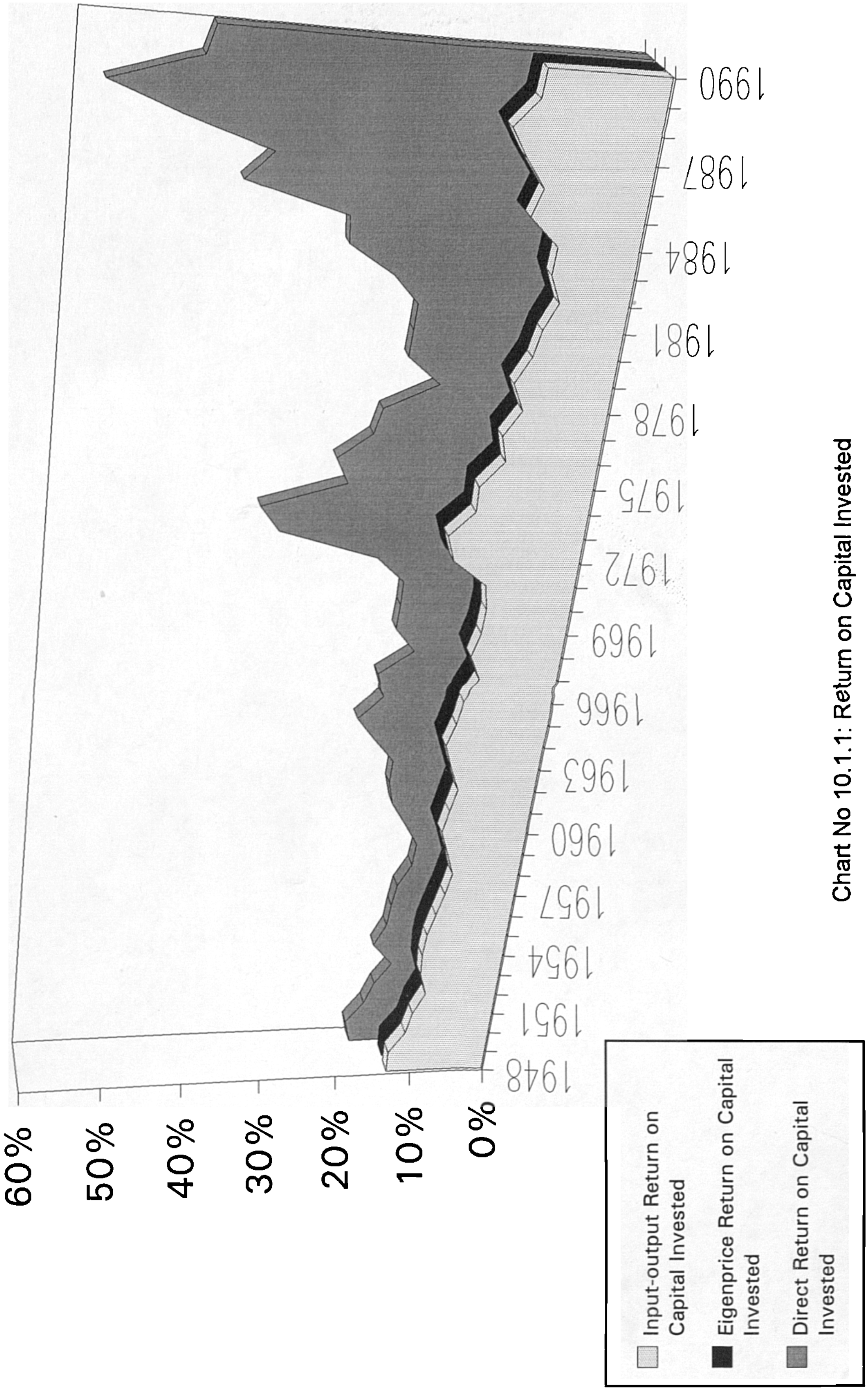


Chart No 10.1.1: Return on Capital Invested

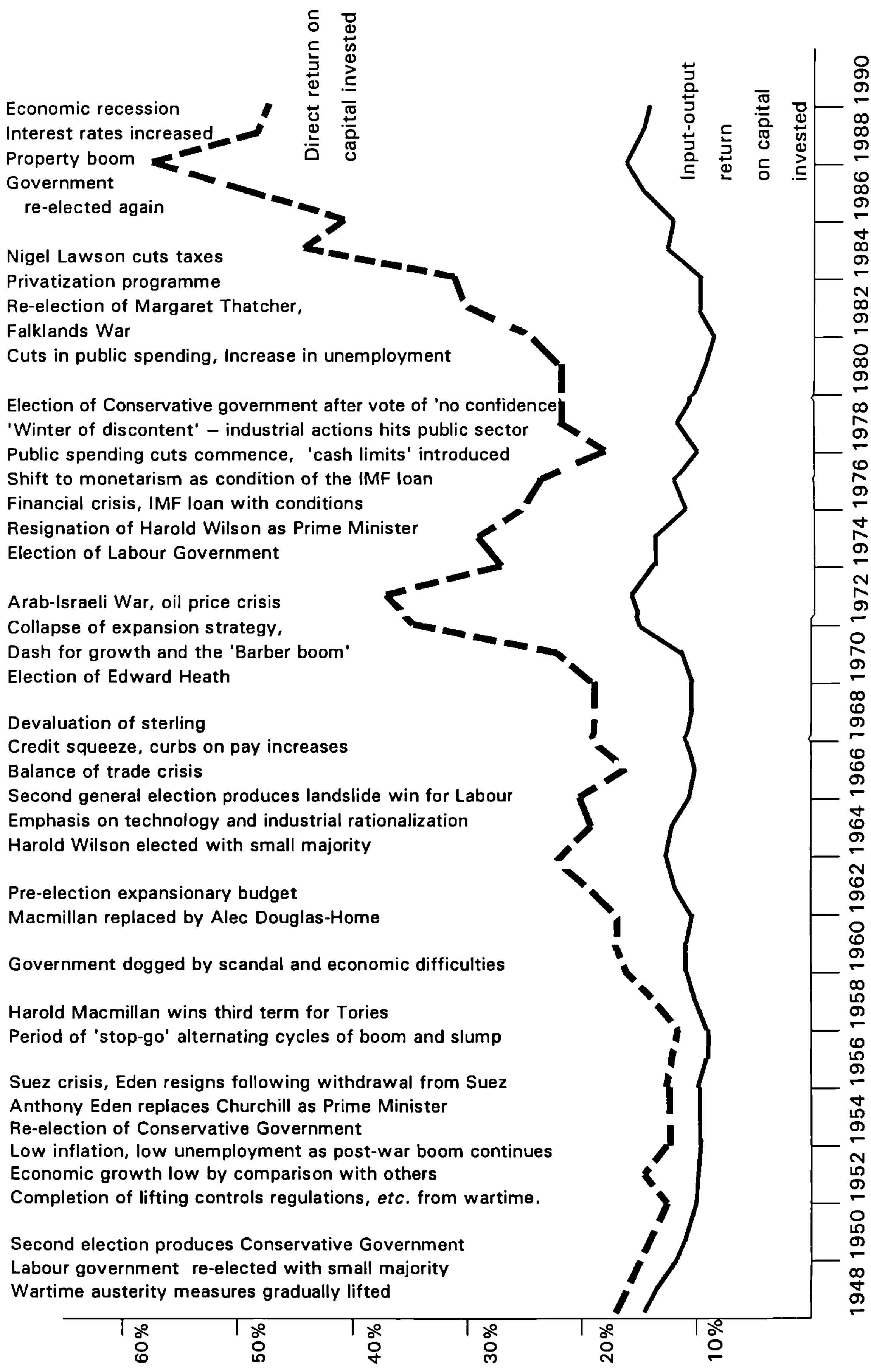


Chart 10.1.2: Economic and political events against capital productivity for the construction industry Source: After Hillebrandt (1984)

10.2: ANALYSIS OF THE RESULTS

10.2.1: Labour intensity of the construction process

The most obvious explanation for the high capital productivity statistics obtained for the construction sector is its labour intensity. This applies to the direct capital productivity measure and to a lesser extent to the input-output measure. Even though the latter 'captures' the hired capital and off-site capital omitted from the direct measure, the synthesization cannot overcome the fact that the construction *process* as opposed to the construction *sector* or *industry* remains a labour-intensive excersise. This explanation fails to identify why the direct capital productivity of construction, increased throughout the post war period of the Case Study while the capital intensity was increasing.

10.2.2: Output multiplier for construction

A more plausible explanation for the high capital productivity figures obtained is to be found in the output multiplier for construction. The high values reflect the backward linkage indicators as illustrated in Table 10.2.2.2 and in Chart 10.2.2.2 below. Construction remains consistantly second behind Agriculture over the last thirty years.

The above illustrates the nature of construction as an assembly industry as argued by Bon (1988). This gives a clue as to how high capital productivity is achieved. This structure enables construction profits to be a high proportion of value added even with the labour intensive nature of the on-site assembly process. This arguement is not contradicted by the general upward trend in the output multiplier for construction over the same time period as the rise in capital productivity for construction.

	1935	1950	1954	1963	1968	1974	1979	1984
Agriculture	1.3831	2.0303	1.9214	1.6809	2.0996	2.2321	2.5704	2.4211
Energy	1.6989	2.0250	2.0968	1.9823	2.0153	2.0454	1.9425	1.9390
Manufacturing	1.6420	1.8143	1.9686	1.8848	1.8719	1.8651	1.7544	1.7606
Construction	1.3662	1.4546	1.3764	1.3367	1.3176	1.4783	1.5136	1.3654
Distribution	1.3435	1.4160	1.5710	1.5620	1.5304	1.5768	1.6005	1.4844
Services	1.0434	1.4423	1.3060	1.3452	1.3182	1.4828	1.4035	1.5419

Table 10.2.2.1: Input multiplier for the UK by industry 1935-1984

	1935	1950	1954	1963	1968	1974	1979	1984
Agriculture	1.4918	1.7270	1.8945	2.0221	2.1192	2.2028	2.1214	2.0928
Energy	1.6313	1.6170	1.6591	1.6339	1.6261	1.6024	1.5810	1.6700
Manufacturing	1.7876	1.8921	2.0221	1.8986	1.9147	1.9297	1.8943	1.8575
Construction	1.7823	1.8764	1.9743	1.9478	1.9468	2.0007	1.9543	2.0307
Distribution	1.2317	1.2662	1.3365	1.4004	1.3451	1.5589	1.5527	1.6402
Services	1.1189	1.2622	1.2053	1.2294	1.2187	1.2991	1.2181	1.2600

Table 10.2.2.2: Output multiplier for the UK by industry 1935-1984

	1935	1950	1954	1963	1968	1974	1979	1984
Agriculture	0.7707	0.8506	0.9860	1.2030	1.0093	0.9869	0.8253	0.8644
Energy	0.8042	0.7985	0.7913	0.8242	0.8069	0.7834	0.8139	0.8612
Manufacturing	1.0506	1.0429	1.0272	1.0073	1.0229	1.0346	1.0798	1.0550
Construction	1.2328	1.2900	1.4344	1.4572	1.4776	1.3533	1.2912	1.4873
Distribution	0.9170	0.8942	0.8507	0.8965	0.8790	0.9887	0.9701	1.1050
Services	0.9259	0.8752	0.9229	0.9140	0.9245	0.8761	0.8679	0.8172

Table 10.2.2.3: Output to input multiplier for the UK by industry 1935-1984

This does not explain why Agriculture with the consistently the highest output multipliers of all industrial sectors does not acheive the high capital productivity of construction. It also fails to identify why the Energy sector, sporadically a high performer on input-output capital productivity has amongst the lowest output multipliers. This issue warrents further study and it will be discussed later in the context of technological and organization change in the sector.

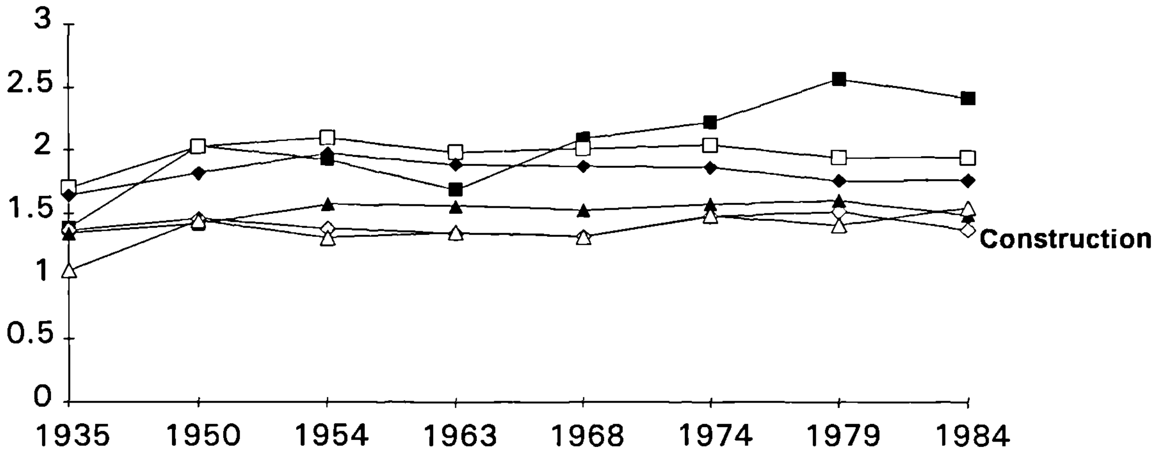


Chart 10.2.2.1: Input multiplier for the UK by industry 1935-1984

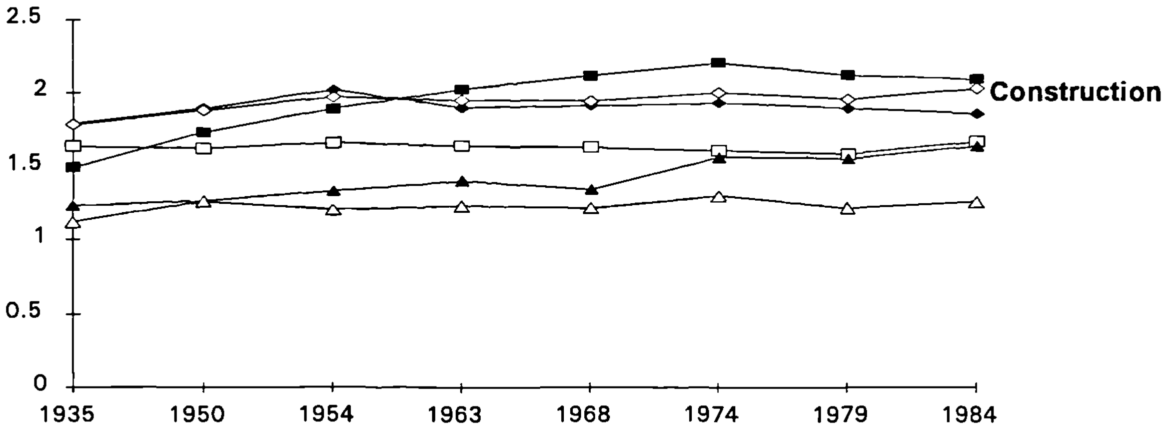


Chart 10.2.2.2: Output multiplier for the UK by industry 1935-1984

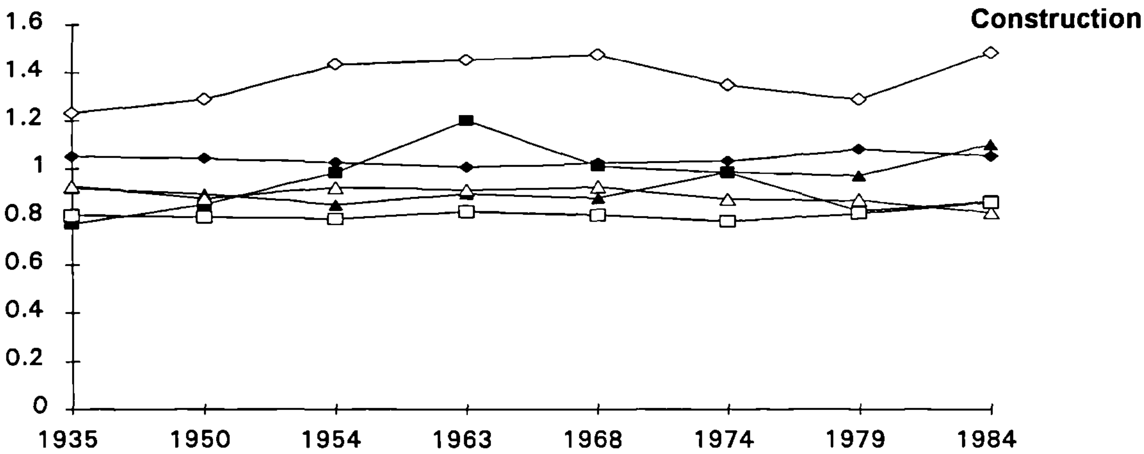
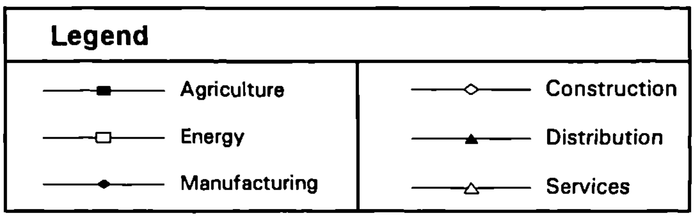


Chart 10.2.2.3: Output to input multiplier for the UK by industry 1935-1984



10.2.3: Input multiplier for construction

The other interesting outcome is the very low value of the input multiplier for construction. Construction is last in virtually all cases over the period of study as indicated in Table 10.2.2.1 and Chart 10.2.2.1 below. The ratio of output to input multiplier thus shows Construction ahead of all other sectors throughout. This is indicative of the nature of construction alongside manufacturing as a producer of capital goods. This might also be worthy of further investigation.

10.2.4: Technological and organizational change

Technological change can take the form of *process innovation*, for example the mechanization of the site-based activities, or *product innovation*, such as system building.

Construction has experienced both of these changes over the period studied. Mechanization of the construction process has proved a constant feature aimed at the reduction of labour costs and speeding up the construction process.

Product innovation, by contrast, has developed in fits and starts. Prefabrication of units off-site has become more common as has the substitution of manufactured components for traditional building materials. System building has come and gone in the UK following some disasterous experiences in the 1960s and 1970s with system built high-rise and medium-rise housing. The use of timber frame housing, after some public relations difficulties, also developed, particularly during the 1980s. A further technological change in the nature of buildings has been the growth of the services engineering inputs, notably air conditioning equipment.

Organizational changes have also been implemented by most UK contractors. The key issue here is that of vertical disintegration; this takes the form of the use of subcontractors, plant hire and ready mix concrete.

10.2.5: Summary of findings

All the above technological and organizational changes will tend to increase the output multiplier for construction. Mechanization coupled with increaced use of plant hire will increase the inputs from other sectors to construction and strengthen the backward linkages as will prefabrication in its various forms. Subcontracting will also have ther same effect by increasing the industrial self-input to the construction sector.

No other obvious explanation is forthcoming for the dynamic performance of construction in terms of capital productivity. Indeed much of the divergence between the performace of construction and the other sectors of the economy takes place after 1984. No benchmark input-output tables have been produced after that time so it is would be surprising if the answer could be found in the input-output multipliers. It remains possible that the outcome could result from a combination of two or more factors including those outlined above.

Additional research is necessary in this area. This could take the form of more detailed comparisons of construction with high performing micro-sectors such as oil and gas production. In addition the development of a dynamic input-output productivity model could prove useful in this context.

10.2.6: Eigenprice structure

The very close correspondence between the input-output productivity figures and the eigenprice returns should give little cause for concern. It is simply a reflection of the eigenprice structure of the UK economy, or at least the one represented in the official statistics. These results are close to those originally published by Seton (1985). Appendix No 5 illustrates the difference between the eigenprice structure of ther UK and that of Eire, Finland, and Japan. The eigenprices obtained in the Case Study reflect the nature and accounting of indirect taxation in the UK.

From a superficial analysis, it would appear that, not only is indirect taxation apparently quite low in the UK but that it apparently varies very little from industry to industry¶. A deeper examination suggests that the method of presenting indirect taxation, in the UK input-output tables, that causes the low price deviancy. The question of whether indirect taxation should be allocated to the industry concerned or to final demand is relevant.

In the 1984 tables, for example, the vast majority of indirect taxation, was set against consumption instead of against the industries concerned. Excise duty, was attributed to consumption in the 1963 tables. Before that, it appeared against the 'tobacco and alcoholic drinks' element of manufacturing. The exception to this, were the tables of 1948, that set all indirect taxation against final demand.

This is an important issue from micro-economics of the point: "who pays indirect taxes?" This relates to the price elasticity of demand for the various products. Thus, for those with low price elasticity of demand, an increase in sales tax would be passed on to the consumer. In other cases, the manufacturer, distributor, or the retailer might have to absorb part or all of the extra costs.

Excise duty, which was traditionally levied on goods with low price elasticity of demand – alcohol, tobacco, petrol, *etc.* This would suggest that the bulk of such taxes would ultimately be paid by the consumer. By contrast, (the former) purchase tax was levied in 'luxury' goods such as jewellery, watches, *and the like.* Here the price elasticity would be expected to be much lower, and the bulk of the taxes might fall on the manufacturer and vendor. A similar argument might be applied to the recently abolished car tax.

¶ This base of VAT in the UK is comparatively narrow although admittedly it is one that is broadening all the time *via* political will and European Community law. For example, considerable changes have been made to the charging of VAT on new construction works since the publication of the most recent tables, notably the recent inclusion of virtually all non-residential 'new build' work within the scope of VAT.

In the case of Value Added Tax, this again could be seen primarily as a tax on the final user. Most taxes on intermediate transactions are, presumably, claimed back if the firm concerned is of sufficient size to be registered.

Despite the intellectual arguments for attributing indirect taxes to consumption, for this model, the bulk ought to be set against the industry concerned. For subsidies, no ambiguity exists, all appears against the appropriate industry, although much may have the effect of reducing prices to the consumer.

Thus, to ensure consistency and to identify distortion in prices, indirect taxes and subsidies really ought to be apportioned between the industries producing the appropriate product instead of set against consumption. However, the figures used in this Thesis are taken as the original input-output tables except the 1948 tables that were brought into line with the 1950 and 1954 tables by apportioning the excise duties between the industrial groups.

The changes in indirect taxation since the 1985 tables ought to have an interesting impact on the eigenprices for the UK, if the tables were presented as argued above. The effects of a changing pattern of subsidies to the energy sector — largely away from coal towards non-fossil sources — may also become clear with the publication of more up-to-date input-output tables. A fundamental reform of the Common Agricultural Policy of the EC could also have profound implications.

10.3: THE MODEL

10.3.1: Evaluation

It is possible to implement the model, at least for time-series and inter-industry comparisons. There is no reason why the international comparisons should not be facilitated by repeating the exercise for one or more country. The main problem so far established is the difficulty of obtaining reliable data for the model. From this viewpoint, the model is open to criticism as somewhat 'information hungry'. It requires vastly more data than, say labour productivity, or even conventional capital productivity. These difficulties are liable to be compounded for any international analysis. The problem of availability of data is common in applied economics research particularly empirical macroeconomic work.

On the positive side, it should be mentioned that the above Case Study was accomplished without experiencing the difficulties inherent with cost indices and the currency exchange problems, outlined in Chapter 1, which traditionally beset measures of productivity.

10.3.3: Conclusions on Case Study

The results show the strengths and the weaknesses of the approach. It is clearly much stronger in terms of time-series analysis of a particular industry than it is comparing industries with markedly different economic structures. The vast disparity in the 'performance' of the different industries illustrates the problems for any single-factor productivity measure when like is not compared with like.

Similar results are expected for international comparisons. Here, it might be useful to check the results against the outcome of alternative approaches to productivity measurement. Thus, for dissimilar industrial structures, the model presents ***one** solution* for assessing performance and not ***the** solution*.

10.4: THE RESEARCH PHILOSOPHY

10.4.1: Assessment using the deductive model

If Popper's (1990) approach to scientific research is followed, progress is made in terms of generating falsifiable hypotheses. The key hypothesis identified in this Thesis is that traditional approaches to productivity measurement are fatally flawed when applied to the construction industry. This has been supported, not by statistical analysis, but by the application of theory. The alternative model, outlined, is presented as at least a partial solution to the problems besetting the traditional approach.

Of Popper's (1990) four steps in testing a theory:

i) The assessment of *internal consistency* presents few problems. While the model has been subjected to as much critical evaluation as possible, to check if it meets the specification, subsequent falsification remains a possibility.

ii) The assessment of the model for *tautology*, was carried out internally. See Lowe (1987c) in reply to Hall & Cheetham (1986) for an example of debate regarding tautology in productivity measurement.

iii) The model was checked against existing literature for *innovation* as far as possible.

iv) The evaluation of a model by empirical testing presents more problems. It is not possible to test the productivity results, obtained in the Case Study, against some *objective* measure of economic efficiency.

Thus the figures can be calculated and the results presented but there are no agreed criteria to test them against. If there was such a universally accepted objective measure, then any new measure would be of no consequence. The results would, thus, be trivial if in accord with the criterion test and wrong otherwise. Such measures remain essentially subjective, and can only, in reality, be tested for internal logic and consistency.

The problem is that such concepts as *productive efficiency* and *allocative efficiency* are not directly measurable. Instead they are assessed by the selection of a *proxy variable* that is amenable to measurement. The various approaches to productivity measurement, outlined in Chapter 2, are examples of finding *proxy variables* deemed suitable, to a lesser or greater extent, for the representation of the above concepts. The superiority of one model over another, is only really decided by theory, as outlined in Paragraph 6.3.1.

The logical and theoretical aspects of the model are amenable to testing. Little progress, in terms of testing the *empirical* validity of the model, can be made using the deductive approach to research.

10.4.2: The paradigm approach

The model fits more comfortably into Kuhn's philosophy. It is not difficult to identify any number of *paradigms* in contemporary economic theory. These will probably take the form of overlapping sets instead of mutually exclusive groups. Thus, most active groups of economists can be categorized as adherents to one or more paradigm theories. Followers of paradigm theories include the more *mainstream* neo-Classical microeconomists, Keynesian macroeconomists, and Monetarists. In addition, there are the post-Keynesian, new Cambridge and Austrian subjectivists and members of the Marxist school.

The differences in perceptions of the followers of the various theories can be all-embracing, in that disputes, can rarely be settled by reference to the facts or empirical observation. This is particularly the case for macroeconomic policy.

There is always sufficient ambiguity in terms of external influences and non-economic factors for apparently negative results for the paradigm theory to be explained away. In such cases, Kuhn (1970) argues that failure to achieve the expected results is generally not seen as a failure in the paradigm theory but as a failure of the experimenter.

10.3.3: Input-output analysis as a paradigm theory

The general approach implicit in input-output analysis can be traced back, earlier than Leontief, to the eighteenth century French economist François Quesney who outlined a similar approach entitled the *Tableau économique* in 1758. Quesnay's model is likened to the Leontief approach by Phillips (1955).

Later, in the nineteenth century, another economist Léon Walras helped to establish general equilibrium theory, a branch of neo-Classical economics within which input-output economics may be placed¶. General equilibrium theory is concerned with the analysis of the economy in its entirety, as a series of subsets of agents, all of which, are simultaneously in equilibrium.

These roots are acknowledged by Leontief (1965) in his definition of the input-output approach as:

> *an adaption of the neo-classical theory of general equilibrium to the empirical study of quantitative interdependence between interrelated economic activities*

General equilibrium as expounded by Walras and others (McKenzie, 1989) in the last century had (and still has) a reputation as an elegant but unrealizable approach. The simplifications inherent in the Leontief approach — linear production functions, constant returns to scale, no joint production, *etc.* — were seen as the

¶ This contention is disputed by Chiang (1974), because of its concentration on technical relationships rather than market equilibrium, and accepted with caveats by Baumol (1977) who argues that the approach is more 'general' than 'equilibrium'.

way to make general equilibrium analysis manageable. It was transformed from an esoteric and impracticable theory into a viable tool of economic analysis and economic planning.

The Leontief input-output approach might not properly be termed as an economic paradigm. It certainly can be argued that its fundamental notion of equilibrium complies with all attributes of a paradigm. It has many worldwide adherents, many of whom are followers of existing paradigms. The approach has attractions to subjectivist and Marxist¶ economists as well as neo-Classical adherents.

It has gained acceptance within the United Nations, the Central Statistical Office in the U.K. and equivalent bodies in many countries. It is the basis for the national accounting process in several countries. The approach has spawned two Nobel prizewinners, Wassily Leontief himself and Richard Stone. There is interest in the approach from regional and urban economists and those interested in industrial interrelationships (Hewings, 1977). This approach has been adapted to produce a multi-regional model (Miller & Blair, 1985). Regional and provincial input-output tables have been developed — *e.g.* for Scotland and Northern Ireland — as have local models. Examples of the latter, include Merseyside (de Kantor & Morrison, 1976) and North Staffordshire (Pullen & Proops, 1983). Also, the approach is favoured by some, for the study of developing economies.

A regular conference series commenced in Holland in 1950 with 15 participants, apart from the Dutch hosts. By 1986, the eighth in the series in Sapporo, Japan, had grown to a major event with 300 participants and 110 papers.

¶ For example the distinguished Polish economist Oskar Lange (1978) argues that the Leontief approach is a development of Marxist economics with the proviso that it was based on an n-sector model rather than the two-sector (production-consumption) model envisaged by Marx. Lange (1978) cites the fact that Leontief was still resident in the USSR when his ideas were first published and that he was well familiar with the works of Marx and Soviet literature.

10.4.4: Current research into Input-output economics

Lynch (1986) identified three groups among the presenters at the Sapporo conference, who may be considered representative of the followers of the paradigm:

a) Compilers of input-output tables, generally these are central government statisticians concerned with the use of the input-output basis for the 'commodity-flow' system of identifying final demand within their respective economies.

b) Users (classical), including those who continue to construct models using the original Input-output framework as formulated *"in tablets of stone"* by Leontief in the 1930s.

c) Users (modern economic modellers), those who use the Input-output approach, do so by embedding the methodology within disaggregated models. They often employ sophisticated econometric techniques.

These three groups bear an uncanny resemblance to Kuhn's three foci for factual scientific investigation: the *determination of facts* (the compilers), the *matching of facts with the [existing paradigm] theory* (classical users), and the *articulation of theory* (modern economic modellers).

Lynch (1986), while impressed by the developments within the latter group of 'modern economic modellers', expressed some concern at the influence of the 'classical' users among the academic researchers at the conference:

> *There remains a disturbingly large number of academics who are happy to continue investigations of a largely theoretical nature based on out-of-date tables and restrictive assumptions...*

This group was contrasted with the 'modern economic modellers' who used more sophisticated approaches to the model structures and relationships on the back of the basic input-output approach.

10.4.5: The model in context

In the light of the above, the approach suggested in this Thesis would appear to fit into latter category of the Lynch typology. The model although based on input-output (in the non-technical sense as well as the Leontief usage) as a unifying discipline, does make use of approaches drawn from different branches of economics. Thus, for example, it employs the Cobb-Douglas (exponential) production function instead of the Leontief linear production function. See Lowe (1986a) for a brief comparison of the two approaches. The approach to capital theory owes far more to the post-Keynesian analysis than the neo-Classical schema normally associated with capital productivity.

Similarly the work fits in with Kuhn's (1970) third focus for 'normal' scientific research, the articulation of the paradigm theory. It is on this basis that the approach stands or falls, not on the minutiae of the empirical results obtained in the Case Study.

10.5: FURTHER WORK

10.5.1: International comparisons

Clearly the priority is to test the model via an international comparison of several countries. This will best be started using a European Community country that is comparable with the UK, preferably a small state with good input-output statistics, say the Netherlands or Denmark. Subsequently the analysis should be used of other OECD countries such as the USA and Japan, and finally, as statistics allow, to the countries of Eastern Europe and South East Asia.

10.5.2: Refinements to the model

Potential refinements to the model might include the use of a higher degree of articulation, both for the input-output model and the capital matrix. For construction, some subdivision into the major components – building, civil engineering, services engineering, *etc.* – might prove useful. However, the SIC classification schema is not particularly helpful. Civil engineering and services engineering are separately identified in Group 502 and 503 respectively. New building and maintenance work are jumbled together in Group 501. To make matters worse, Group 500 contains a *hotchpotch* of different activities including 'plant hire with operatives', 'demolition specialists', DLOs, and those firms unable to decide whether to classify under 501 or 502! The only data published in the UK at the SIC group level are included in *Business Monitor* PA500 for registered firms employing more than 20 employees. Small firms are grouped together for publication, while unregistered firms are ignored by this data series. The issues raised in Section 10.2.2 of comparisons with micro-sectors could be facilitated by this approach.

It may make more sense to subdivide construction, into 'new build' and 'repair and maintenance'. No problems should be experienced with the output side, since all intermediate outputs (bar industrial self-input) are, by definition repair and maintenance, as is all final demand apart from that classified as investment. The input side of the model could give more problems since both intermediate inputs to construction and value added must be disaggregated into the two groups. See Lowe (1989) for an example of this approach.

The subdivision of the capital used, could be achieved either by using econometric techniques (Klein, 1989), or by traditional input-output methodology. Additional data from subsequent (1989 onwards) input-output tables to augment the current sketchy post 1968 data might help with this task. This should improve the quality of assumptions on asset life and depreciation.

Finally, anything to improve the quality of the data used, either by refinement of existing sources or else the identification of more accurate sources will be of great help to the reliability of the results. Further work on adapting the input-output tables to ensure conformity may prove useful.

10.5.3: Fundamental developments

Further work on the model will probably involve a shift to a dynamic input-output model to examine the effects of investment on inter-industrial relationships. The approach of Johansen (1986) is a good example. Also relevant is the approach suggested by Beke (198), that involved a dynamic input-output model based on a lagged model of the construction process. This is intended to identify local and sectoral multipliers for the construction industry. The use of dynamic analysis will give insight into the forward linkages from construction *via* investment goods for which the static model is incapable of handling. It may help to explain the high capital productivity figures demonstrated in the Case Study in terms of high output multipliers.

Also, the development of multi-factor or labour productivity measures consistent with the model might prove useful. The technique used by Ochoa (1986) warrants further investigation in this respect.

Finally, more consideration of the backward linkages could prove useful. This would involve study of the structure of the various extractive, manufacturing, and service industries that provide the main intermediate inputs into construction (Lowe, 1987a) and their linkages.

POSTSCRIPT

The government are very keen on amassing statistics. They collect them, raise them to the n-th power, take the cube root and prepare wonderful diagrams. But you must never forget that every one of these figures comes in the first instance from the village watchman who puts down what he damn well pleases.

Anonymous
quoted by Josua Stamp

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One man deserves the credit,
one man deserves the blame,
and Nicolai Ivanovich Lobachevsky is his name.

Tom Lehrer

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INDEX

Every chapter I stole from somewhere else.
Index I copy from old Vladivostok telephone directory.

Tom Lehrer

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APPENDIX NO 1:
INPUT-OUTPUT TABLES

Incompatible data are useless data

Wassily Leontief

A1.1: Derivation of the symmetrical tables

Tables:

Table A1.1: Example of derivation of symmetrical tables

Notes:

The above table gives an example of the derivation of the symmetrical industry-by-industry and commodity-by-commodity tables for 1984 using assumptions of industry, commodity and hybrid technology. It should be emphasised that this will not necessarily correspond to the actual table, for 1984, used in the calculation, which was derived from the basic tables in disaggregated [102 x 102] format and then aggregated to the [6 x 6] format.

A1.2: Adjustments required

A1.2.1: Generally

The tables are presented in a comparable format using the six-industry aggregation based on the 1980 SIC, with both final demand and value added similarly aggregated into four categories each. In most cases this involved no greater problem than adding together rows and columns. Only two industries produced difficulties; both of which stemmed from significant changes in the SIC:

a) The service industries tended to be presented with the distribution, transportation, and communication sectors in earlier years.

b) The mining and quarrying industry is split under the 1980 SIC into the energy and water supply group (coal mining) and the manufacturing sector (other mining and quarrying).

c) Inconsistency in the handling of indirect taxation, such as excise duty and VAT, about whether to set such against the industry concerned or against consumption

In addition there are inconsistencies in the presentation of intra-industrial flows in the various tables published over the years.

Table A1.1: Example of derivation of symmetrical tables

Make matrix M'

The output of commodities produced by each industry

Industry / Commodity	Agric	Energy	Manuf	Constr	Distrib	Services	Commodity output
Agriculture	15103	0	16	0	0	0	15119
Energy	0	59429	253	0	0	0	59682
Manufacture	0	133	180026	0	0	307	180466
Construction	122	1024	420	42284	0	0	43850
Distribution	0	83	4249	68	89653	0	94053
Services	0	39	333	0	0	86061	86433
Industry output	15225	60708	185298	42352	89653	86368	479604

Absorption matrix

Industry / Commodity	Agric	Energy	Manuf	Constr	Distrib	Services	Commodity Input	Cons	Govmt	GDFCF	Stocks	Exports	FD	Total
Agriculture	2300	0	8733	6	323	30	11392	2218	124	0	26	1359	3727	15119
Energy	606	17270	6639	557	4461	1464	30997	10584	2374	25	-1005	16707	28685	59682
Manufacture	4178	2891	47659	8506	11488	6057	80779	28470	9320	13288	353	48255	99686	180465
Construction	119	32	507	8841	800	1383	11682	2639	2562	26597	51	321	32170	43852
Distribution	601	1823	12004	1352	6960	1920	24660	49543	3590	1994	-48	14314	69393	94053
Services	960	890	10373	4094	10413	27781	54511	42038	47920	2593	-3	6796	99344	153855
Industry input	8764	22906	85915	23356	34445	38635	214021	135492	65890	44497	-626	87752	333005	547026
Imports	1090	9529	29911	1764	4848	1613	48755	25647	4891	10891	737	1948	44114	92869
Sales by fd	15	41	1245	118	212	207	1838	3762	-4591	-2498	-1	1490	-1838	0
Wages	1616	6064	49940	9115	33960	79358	180053							180053
Profits	4606	24542	16104	7949	14343	27541	95085							95085
Taxes less Subsidies	-639	-1161	2978	442	2554	3098	7272	31011	3697	2218	7	776	37709	44981
Value Added	6688	39015	100178	19388	55917	111817	333003	195912	69887	55108	117	91966	412990	960014

Table A1.1: Example of derivation of symmetrical tables

Table A1.1: Example of derivation of symmetrical tables (Cont)

Z matrix	Agric	Energy	Manuf	Constr	Distrib	Services
Agriculture	15225	0	0	0	0	0
Energy	0	60708	0	0	0	0
Manufacture	0	0	185298	0	0	0
Construction	0	0	0	42352	0	0
Distribution	0	0	0	0	89653	0
Services	0	0	0	0	0	86368

Z matrix inverse					
6.57E-05	0	0	0	0	0
0	1.65E-05	0	0	0	0
0	0	5.4E-06	0	0	0
0	0	0	2.36E-05	0	0
0	0	0	0	1.12E-05	0
0	0	0	0	0	1.16E-05

Q matrix						
Agriculture	15119	0	0	0	0	0
Energy	0	59682	0	0	0	0
Manufacture	0	0	180466	0	0	0
Construction	0	0	0	43850	0	0
Distribution	0	0	0	0	94053	0
Services	0	0	0	0	0	86433

Q matrix inverse					
6.61E-05	0	0	0	0	0
0	1.68E-05	0	0	0	0
0	0	5.54E-06	0	0	0
0	0	0	2.28E-05	0	0
0	0	0	0	1.06E-05	0
0	0	0	0	0	1.16E-05

Tranpose of Make matrix	M						Industry output
Agriculture	15103	0	0	122	0	0	15225
Energy	0	59429	133	1024	83	39	60708
Manufacture	16	253	180026	420	4249	333	185298
Construction	0	0	0	42284	68	0	42352
Distribution	0	0	0	0	89653	0	89653
Services	0	0	307	0	0	86061	86368
Commodity output	15119	59682	180466	43850	94053	86433	

Intermediate Transactions part of Absorption matrix (coefficient form)					U	
Agriculture	0.1521	0.0000	0.5776	0.0004	0.0214	0.0020
Energy	0.0102	0.2894	0.1112	0.0093	0.0747	0.0245
Manufacture	0.0232	0.0160	0.2641	0.0471	0.0637	0.0336
Construction	0.0027	0.0007	0.0116	0.2016	0.0182	0.0315
Distribution	0.0064	0.0194	0.1276	0.0144	0.0740	0.0204
Services	0.0062	0.0058	0.0674	0.0266	0.0677	0.1806

Table A1.1: Example of derivation of symmetrical tables

Table A1.1: Example of derivation of symmetrical tables (Cont)												
	Agric	Energy	Manuf	Constr	Distrib	Services	Agric	Energy	Manuf	Constr	Distrib	Services
Product Mix matrix							Inverse of Product Mix matrix					
G = M Z inverse												
Agriculture	0.9920	0.0000	0.0001	0.0000	0.0000	0.0000	1.0081	0.0000	-0.0001	0.0000	0.0000	0.0000
Energy	0.0000	0.9789	0.0014	0.0000	0.0000	0.0000	0.0000	1.0215	-0.0014	0.0000	0.0000	0.0000
Manufacture	0.0000	0.0022	0.9716	0.0000	0.0000	0.0036	0.0000	-0.0023	1.0293	0.0000	0.0000	-0.0037
Construction	0.0080	0.0169	0.0023	0.9984	0.0000	0.0000	-0.0081	-0.0173	-0.0023	1.0016	0.0000	0.0000
Distribution	0.0000	0.0014	0.0229	0.0016	1.0000	0.0000	0.0000	-0.0013	-0.0236	-0.0016	1.0000	0.0001
Services	0.0000	0.0006	0.0018	0.0000	0.0000	0.9964	0.0000	-0.0007	-0.0019	0.0000	0.0000	1.0036
Market Share Matrix												
S = M' Q inverse												
Agriculture	0.9989	0.0000	0.0000	0.0028	0.0000	0.0000						
Energy	0.0000	0.9958	0.0007	0.0234	0.0009	0.0005						
Manufacture	0.0011	0.0042	0.9976	0.0096	0.0452	0.0039						
Construction	0.0000	0.0000	0.0000	0.9643	0.0007	0.0000						
Distribution	0.0000	0.0000	0.0000	0.0000	0.9532	0.0000						
Services	0.0000	0.0000	0.0017	0.0000	0.0000	0.9957						
Commodity-by-commodity matrix			(Commodity technology)						(Industry technology)			
(coefficient form)			Ec = U G inverse						Ei = U S			
Agriculture	0.1534	-0.0014	0.5940	0.0004	0.0214	-0.0001	0.1526	0.0024	0.5762	0.0063	0.0465	0.0042
Energy	0.0102	0.2951	0.1123	0.0092	0.0747	0.0242	0.0103	0.2886	0.1112	0.0169	0.0765	0.0250
Manufacture	0.0230	0.0148	0.2701	0.0471	0.0637	0.0327	0.0234	0.0171	0.2635	0.0484	0.0727	0.0344
Construction	0.0011	-0.0028	0.0109	0.2019	0.0182	0.0316	0.0027	0.0008	0.0116	0.1945	0.0181	0.0314
Distribution	0.0063	0.0191	0.1295	0.0143	0.0740	0.0200	0.0065	0.0198	0.1274	0.0156	0.0763	0.0208
Services	0.0061	0.0051	0.0674	0.0265	0.0677	0.1810	0.0063	0.0060	0.0676	0.0265	0.0676	0.1801
Industry-by-industry matrix			(Commodity technology)						(Industry technology)			
(coefficient form)			Ac = G inverse U						Ai = S U			
Agriculture	0.1534	0.0000	0.5823	0.0004	0.0215	0.0020	0.1520	0.0000	0.5770	0.0010	0.0214	0.0021
Energy	0.0103	0.2956	0.1133	0.0095	0.0763	0.0250	0.0102	0.2882	0.1114	0.0141	0.0750	0.0253
Manufacture	0.0238	0.0158	0.2713	0.0484	0.0651	0.0338	0.0236	0.0181	0.2707	0.0497	0.0676	0.0355
Construction	0.0013	-0.0043	0.0044	0.2017	0.0167	0.0311	0.0026	0.0007	0.0112	0.1944	0.0176	0.0304
Distribution	0.0058	0.0186	0.1212	0.0129	0.0724	0.0196	0.0061	0.0185	0.1217	0.0137	0.0705	0.0195
Services	0.0062	0.0056	0.0671	0.0266	0.0678	0.1811	0.0063	0.0058	0.0676	0.0266	0.0675	0.1798

Table A1.1: Example of derivation of symmetrical tables

Table A1.1: Example of derivation of symmetrical tables (Cont)														
	Agric	Energy	Manuf	Constr	Distrib	Services		Agric	Energy	Manuf	Constr	Distrib	Services	
Make matrix (Commodity Technology)				M1'			Commodity output	Make matrix transpose (Commodity Technology)						M1
Agriculture	15103	0	0	0	0	0	15103	15103	0	0	0	0	0	15103
Energy	0	59429	0	0	0	0	59429	0	59429	0	0	0	39	59468
Manufacture	0	0	180026.4	0	0	307	180333	0	0	180026	420	4249	0	184696
Construction	0	0	420	42284	0	0	42704	0	0	0	42284	68	0	42352
Distribution	0	0	4249	68	89653	0	93970	0	0	0	0	89653	0	89653
Services	0	39	0	0	0	86061	86100	0	0	307	0	0	86061	86368
Industry output	15103	59468	184695.8	42352	89653	86368	477639.8	15103	59429	180333	42704	93970	86100	477640
Make matrix (Industry Technology)				M2'			Commodity output							
Agriculture	0	0	16	0	0	0	16							
Energy	0	0	253	0	0	0	253							
Manufacture	0	133	0	0	0	0	133							
Construction	122	1024	0	0	0	0	1146							
Distribution	0	83	0	0	0	0	83							
Services	0	0	333	0	0	0	333							
Industry output	122	1240	602	0	0	0	1964							
Product Mix matrix								Product Mix matrix inverse						
G1 = M1 Z inverse														
Agriculture	0.9920	0.0000	0.0000	0.0000	0.0000	0.0000		1.0081	0.0000	0.0000	0.0000	0.0000	0.0000	
Energy	0.0000	0.9789	0.0000	0.0000	0.0000	0.0005		0.0000	1.0215	0.0000	0.0000	0.0000	-0.0005	
Manufacture	0.0000	0.0000	0.9716	0.0099	0.0474	0.0000		0.0000	0.0000	1.0293	-0.0102	-0.0488	0.0000	
Construction	0.0000	0.0000	0.0000	0.9984	0.0008	0.0000		0.0000	0.0000	0.0000	1.0016	-0.0008	0.0000	
Distribution	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000		0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	
Services	0.0000	0.0000	0.0017	0.0000	0.0000	0.9964		0.0000	0.0000	-0.0017	0.0000	0.0001	1.0036	
Market Share matrix							Column	matrix [I - S^2]						
S2 = M2' Q inverse							Sums							
Agriculture	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.008069	0.9919	0	0	0	0	0	
Energy	0.0000	0.0000	0.0014	0.0000	0.0000	0.0000	0.020777	0	0.9792	0	0	0	0	
Manufacture	0.0000	0.0022	0.0000	0.0000	0.0000	0.0000	0.003336	0	0	0.9967	0	0	0	
Construction	0.0081	0.0172	0.0000	0.0000	0.0000	0.0000	0	0	0	0	1	0	0	
Distribution	0.0000	0.0014	0.0000	0.0000	0.0000	0.0000	0	0	0	0	0	1	0	
Services	0.0000	0.0000	0.0018	0.0000	0.0000	0.0000	0	0	0	0	0	0	1	

Table A1.1: Example of derivation of symmetrical tables

Table A1.1: Example of derivation of symmetrical tables (Cont)						
	Agric	Energy	Manuf	Constr	Distrib	Services
Hybrid Technology matrix						
H = G1 inverse[I - S^2] + S2						
Agriculture	0.9999	0.0000	0.0001	0.0000	0.0000	0.0000
Energy	0.0000	1.0003	0.0014	0.0000	0.0000	-0.0005
Manufacture	0.0000	0.0022	1.0258	-0.0102	-0.0488	0.0000
Construction	0.0081	0.0172	0.0000	1.0016	-0.0008	0.0000
Distribution	0.0000	0.0014	0.0000	0.0000	1.0000	0.0000
Services	0.0000	0.0000	0.0001	0.0000	0.0001	1.0036
Commodity-by-commodity matrix				(Hybrid technology)		
(coefficient form)				Eh = U H		
Agriculture	0.1521	0.0013	0.5926	-0.0055	-0.0068	0.0020
Energy	0.0102	0.2900	0.1145	0.0082	0.0693	0.0245
Manufacture	0.0235	0.0175	0.2709	0.0445	0.0507	0.0337
Construction	0.0043	0.0042	0.0119	0.2018	0.0175	0.0317
Distribution	0.0065	0.0200	0.1310	0.0131	0.0678	0.0205
Services	0.0065	0.0065	0.0692	0.0260	0.0644	0.1812
Industry-by-industry matrix				(Hybrid technology)		
(coefficient form)				Ah = H U		
Agriculture	0.1521	0.0000	0.5776	0.0004	0.0214	0.0020
Energy	0.0102	0.2895	0.1116	0.0094	0.0748	0.0245
Manufacture	0.0234	0.0161	0.2648	0.0456	0.0617	0.0332
Construction	0.0041	0.0057	0.0181	0.2021	0.0197	0.0320
Distribution	0.0064	0.0198	0.1278	0.0144	0.0741	0.0204
Services	0.0063	0.0058	0.0677	0.0267	0.0679	0.1812

Table A1.1: Example of derivation of symmetrical tables

A1.2.2: Services

The main difficulty encountered with the input-output tables stemmed from the inclusion of distribution, transport, and communication with services for the 1948, 1950 and 1954 tables.

To produce a six-industry aggregation in conformity with that used for the subsequent tables involved the disaggregation of the 'services' row and column.

As a starting point the services element in the [47 x 50] tables for 1948 were disaggregated. This proved to be comparatively easy since it was already disaggregated by input. The column sums were employed as control figures for the row totals. The intermediate inputs were disaggregated in line with the 1963 tables taking account of the 1935 figures. The final demand totals were similarly split and adjustments made to ensure that the row totals conformed with the control (column) totals. Although this table was subsequently not used, this exercise proved useful as a guide to dealing with the summary tables for 1948 and 1950 and also the benchmark tables for 1954.

The above process was than repeated for the [46 x 46] 1954 tables, except that in this case the disaggregation process involved the column as well as the row. The proportions from the 1948 and the 1963 totals were used for intermediate output and inputs. The value added figures were disaggregated using the *Blue Book* entries for 1954. The column sums were then used as controls for the row totals to enable the final demand elements to be split.

Finally the [11 x 11] summary table for 1950 and the [8 x 8] summary tables for 1948 were treated in a similar way.

A1.2.3: Mining and quarrying

Similar difficulties were experienced for the mining and quarrying elements for the 1948 and 1950 tables in that 'coal mining' needed to be separated from 'other mining and quarrying', the former being allocated to energy and water supply and the latter to manufacturing. This was carried out as above.

A1.2.4: Industrial self-input

Before 1984, industrial self-input was not included within the row and column totals for the tables. Mostly, it was presented in brackets on the leading diagonal of the flow matrix thus easing recomputation. This was not the situation for the summary tables of 1948, 1950, and 1973 or for the benchmark tables of 1954.

a) For the 1973 tables, the intra-industry flows were derived using the industry domestic output figure published within the 'industry and commodity balances' less the total output figures from the industry by industry flow matrix.

b) For the 1954 tables, the intra-industry figure in the absorption matrix is scaled from commodity-by-industry figures. It is multiplied by the appropriate entry from the leading diagonal of the make matrix and divided by the make matrix column total.

c) For the summary tables of 1948 and 1950, the flow is estimated having regard to the coefficients in the 1935 and 1954 tables.

A1.3: Input-output tables

A1.3.1: Industry-by-industry flow matrices

Table:

Table A1.3.1: Industry-by-industry flow matrices 1935-86

Notes:

The six-industry aggregations with adjustments as outlined in Appendix A1.2 above are presented in Table A.1.3.1. The matrix for 1948 was derived from the summary table published in the *Blue Book* instead of the more detailed tables, which were found to be incompatible in format. The matrix for 1935 is presented for purposes of comparison.

As well as the adjustments already outlined, some obvious errors were detected and corrected. For example, in the 1974 tables, the intra-industry flow for industry number 102 ('other services') is stated as £13032.0M. This corresponds to the entry on the leading diagonal of the make matrix and is clearly wrong by a magnitude of *circa* 10. The entry used was derived from the appropriate entry in the absorption matrix scaled to industry technology assumptions as in A1.2.4 (b) above. Equally, the value added and final demand entries were omitted from the industry-by-industry tables for 1984 supplied on diskette by the CSO, the entries were taken from the commodity-by-commodity tables.

The indirect taxation was left as the published tables despite the inconsistency between figures before 1968. The tables for 1948, where initially, all was set against consumption, were adjusted to bring it into line with the 1950 tables. The proportion of indirect taxation was kept constant with that for 1950.

Table A1.3.1: Industry-by-Industry Flow Matrices 1935-1985

1935	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Final Demand	Total Output
Agriculture, Forestry and Fishing	11.3	0.0	59.6	0.0	2.0	0.2	230.7	303.8
Energy and Water Supply	0.8	62.8	68.0	1.5	34.0	4.5	217.4	389.0
Manufacture	69.5	28.8	977.8	137.2	97.5	15.9	1922.1	3248.8
Construction	0.0	0.0	0.1	22.9	31.1	95.0	321.5	470.6
Distribution, Transportation, and Commumication	35.5	16.7	166.6	22.4	115.0	46.0	1298.4	1700.6
Services	0.9	2.4	6.7	10.0	15.0	8.0	1305.5	1348.5
Value Added	185.8	278.3	1970.0	276.6	1406.0	1178.9		
Total Input	303.8	389.0	3248.8	470.6	1700.6	1348.5		
1948	**Agriculture**	**Energy**	**Manufacture**	**Construction**	**Distribution**	**Services**	**Final Demand**	**Total Output**
Agriculture, Forestry and Fishing	23.5	0.0	488.0	0.0	2.0	0.0	425.3	938.8
Energy and Water Supply	7.3	174.1	290.7	3.4	77.0	29.0	395.9	977.3
Manufacture	150.8	117.4	3662.8	350.6	202.0	137.0	6364.5	10985.1
Construction	15.0	22.2	77.8	158.0	64.4	38.6	898.5	1274.5
Distribution, Transportation, and Commumication	60.0	39.2	379.2	42.0	6.8	1.0	2128.8	2657.0
Services	40.0	31.6	265.1	28.0	2.5	1.7	2694.7	3063.5
Value Added	642.3	592.8	5821.6	692.5	2302.3	2856.2		
Total Input	938.8	977.2	10985.2	1274.5	2657.0	3063.5		
1950	**Agriculture**	**Energy**	**Manufacture**	**Construction**	**Distribution**	**Services**	**Final Demand**	**Total Output**
Agriculture, Forestry and Fishing	27.8	0.0	608.0	0.0	1.0	0.0	490.0	1126.8
Energy and Water Supply	9.3	141.8	304.2	8.9	91.7	52.3	441.7	1050.0
Manufacture	299.7	140.0	4531.0	419.1	282.1	173.9	6892.3	12738.1
Construction	30.0	22.2	57.8	178.7	79.4	47.6	1018.0	1433.7
Distribution, Transportation, and Commumication	63.0	63.3	548.9	42.3	6.2	0.9	2457.7	3182.3
Services	42.0	25.3	352.5	47.7	5.2	3.5	1463.3	1939.5
Value Added	655.0	657.3	6335.7	737.0	2716.7	1661.3		
Total Input	1126.8	1049.8	12738.2	1433.7	3182.3	1939.5		

Table A1.3.1: Industry by Industry Flow Matrices 1935-1985

Table A1.3.1: Industry-by-Industry Flow Matrices 1935-1985 (Cont)

1954	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Final Demand	Total Output
Agriculture, Forestry and Fishing	33.0	0.0	609.9	0.0	0.0	0.0	729.0	1371.9
Energy and Water Supply	21.0	226.9	393.9	6.5	153.5	90.5	621.0	1513.3
Manufacture	428.0	194.7	7865.5	603.0	490.3	414.7	9472.0	19468.1
Construction	35.0	26.0	61.0	242.6	71.4	30.6	1467.0	1933.6
Distribution, Transportation, and Commumication	91.2	91.8	973.4	64.9	9.0	1.3	2952.4	4184.0
Services	60.8	44.3	633.5	73.1	7.3	4.8	4322.9	5146.7
Value Added	703.2	930.6	8932.9	943.2	3447.5	4603.7		
Total Input	1372.2	1514.2	19470.1	1933.3	4178.9	5145.7		
1963	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Final Demand	Total Output
Agriculture, Forestry and Fishing	277.5	0.6	444.3	0.0	3.8	9.5	1208.5	1944.2
Energy and Water Supply	21.2	422.7	658.5	13.1	147.6	101.7	1179.7	2544.5
Manufacture	536.1	344.7	8822.4	1112.8	789.9	733.8	12435.8	24775.5
Construction	30.3	22.4	91.7	656.9	78.0	34.0	2989.2	3902.5
Distribution, Transportation, and Commumication	143.7	109.2	1459.9	102.1	734.7	202.5	5727.9	8480.0
Services	92.2	57.0	1069.7	115.7	378.9	257.0	7811.5	9782.0
Value Added	843.2	1587.9	12229.0	1901.9	6347.1	8443.5		
Total Input	1944.2	2544.5	24775.5	3902.5	8480.0	9782.0		
1968	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Final Demand	Total Output
Agriculture, Forestry and Fishing	479.5	0.9	923.6	0.0	5.9	10.6	1089.9	2510.4
Energy and Water Supply	58.1	784.4	1087.6	45.3	277.4	158.5	1953.6	4364.9
Manufacture	738.0	390.3	11789.8	1735.9	835.1	1032.5	17119.2	33640.8
Construction	43.5	63.4	160.6	951.1	43.6	27.2	4615.7	5905.1
Distribution, Transportation, and Commumication	94.4	296.6	1584.8	116.9	954.8	336.6	7592.3	10976.4
Services	60.9	152.5	1663.9	151.7	292.6	388.1	12088.0	14797.7
Value Added	1035.5	2677.1	16431.8	2904.3	8566.0	12844.2		
Total Input	2509.9	4365.2	33642.1	5905.2	10975.4	14797.7		

Table A1.3.1: Industry by Industry Flow Matrices 1935-1985

Table A1.3.1: Industry-by-Industry Flow Matrices 1935-1985 (Cont)								
1970	**Agriculture**	**Energy**	**Manufacture**	**Construction**	**Distribution**	**Services**	**Final Demand**	**Total Output**
Agriculture, Forestry and Fishing	549.3	1.2	1018.0	0.0	6.7	11.2	1312.4	2898.8
Energy and Water Supply	67.1	755.4	1238.9	50.5	307.7	176.1	2137.2	4732.9
Manufacture	853.1	489.6	15013.2	1971.9	969.8	1470.9	20831.8	41600.3
Construction	49.8	133.8	218.4	931.4	43.2	45.4	5040.6	6462.6
Distribution, Transportation, and Communication	96.1	317.4	2222.1	142.9	1023.2	488.8	8510.0	12800.5
Services	80.3	196.3	2314.2	164.0	280.8	532.7	14968.5	18536.8
Value Added	1202.5	2836.7	19578.5	3202.2	10169.3	15811.2		
Total Input	2898.2	4730.4	41603.3	6462.9	12800.7	18536.3		
1971	**Agriculture**	**Energy**	**Manufacture**	**Construction**	**Distribution**	**Services**	**Final Demand**	**Total Output**
Agriculture, Forestry and Fishing	663.9	1.8	1233.7	0.0	7.3	11.6	1263.9	3182.2
Energy and Water Supply	78.0	873.0	1318.3	60.2	393.0	178.0	2458.3	5358.8
Manufacture	869.8	383.2	15039.6	2249.7	1209.6	1419.5	22846.3	44017.7
Construction	53.2	150.4	211.9	964.7	50.6	38.2	5718.2	7187.2
Distribution, Transportation, and Communication	131.7	352.2	2571.2	186.9	1399.7	518.8	9685.1	14845.6
Services	106.4	226.1	2886.4	232.2	419.9	610.2	17069.2	21550.4
Value Added	1278.9	3370.5	20757.8	3493.2	11365.7	18774.9		
Total Input	3181.9	5357.2	44018.9	7186.9	14845.8	21551.2		
1972	**Agriculture**	**Energy**	**Manufacture**	**Construction**	**Distribution**	**Services**	**Final Demand**	**Total Output**
Agriculture, Forestry and Fishing	815.5	2.3	1462.2	0.0	8.2	31.6	1381.5	3701.3
Energy and Water Supply	89.6	990.9	1416.2	67.2	395.8	195.7	2663.4	5818.8
Manufacture	917.2	511.6	15825.2	2410.9	1210.4	1831.8	24568.0	47275.1
Construction	53.8	160.7	184.0	854.3	44.8	48.6	6725.7	8071.9
Distribution, Transportation, and Communication	154.2	310.7	2813.0	190.5	1485.3	627.1	10642.2	16223.0
Services	104.8	226.3	2788.5	218.0	399.4	819.3	19874.4	24430.7
Value Added	1565.5	3614.7	22788.4	4331.3	12678.6	20876.5		
Total Input	3700.6	5817.2	47277.5	8072.2	16222.5	24430.6		

Table A1.3.1: Industry by Industry Flow Matrices 1935-1985

Table A1.3.1: Industry-by-Industry Flow Matrices 1935-1985 (Cont)

1973	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Final Demand	Total Output
Agriculture, Forestry and Fishing	955.3	2.2	1833.8	0.0	9.0	41.1	1701.1	4542.5
Energy and Water Supply	96.7	795.3	1645.3	82.2	460.5	246.2	3175.3	6501.5
Manufacture	1229.6	788.6	9179.9	2824.6	1327.9	2298.9	29818.9	47468.4
Construction	98.2	171.0	182.5	2269.8	43.5	52.8	8531.3	11349.1
Distribution, Transportation, and Communication	146.3	377.1	3313.5	238.5	1250.6	865.2	12223.8	18415.0
Services	142.1	328.1	3544.3	298.9	578.1	939.8	22662.3	28493.6
Value Added	1874.6	4038.4	27770.0	5634.8	14745.2	24049.7		
Total Input	4542.8	6500.7	47469.3	11348.8	18414.8	28493.7		
1974	**Agriculture**	**Energy**	**Manufacture**	**Construction**	**Distribution**	**Services**	**Final Demand**	**Total Output**
Agriculture, Forestry and Fishing	1134.7	0.0	2012.3	0.9	147.4	17.9	1999.9	5313.1
Energy and Water Supply	99.4	1932.8	2904.7	96.0	962.2	300.1	4893.3	11188.5
Manufacture	1428.6	788.7	22521.7	3543.4	3181.1	1596.1	35635.2	68694.8
Construction	117.2	239.3	255.0	3085.1	197.7	365.3	9624.5	13884.1
Distribution, Transportation, and Communication	266.2	531.9	4104.7	357.9	3150.7	1010.8	18896.5	28318.7
Services	250.5	625.7	3395.0	130.4	1936.9	3065.0	23657.5	33061.0
Value Added	2016.4	7067.0	33493.6	6673.4	18748.0	26708.2		
Total Input	5313.0	11185.4	68687.0	13887.1	28324.0	33063.4		
1979	**Agriculture**	**Energy**	**Manufacture**	**Construction**	**Distribution**	**Services**	**Final Demand**	**Total Output**
Agriculture, Forestry and Fishing	1911.0	0.0	6550.0	4.0	156.0	0.0	1987.0	10608.0
Energy and Water Supply	372.0	6680.0	5978.0	158.0	2629.0	235.0	14925.0	30977.0
Manufacture	2772.0	1815.0	39581.0	5679.0	8350.0	2556.0	79284.0	140037.0
Construction	78.0	802.0	274.0	6153.0	582.0	1012.0	18172.0	27073.0
Distribution, Transportation, and Communication	702.0	1197.0	11275.0	1568.0	6473.0	2735.0	43460.0	67410.0
Services	624.0	470.0	7283.0	296.0	4732.0	2529.0	50645.0	66579.0
Value Added	4149.0	20013.0	69096.0	13215.0	44488.0	57512.0		
Total Input	10608.0	30977.0	140037.0	27073.0	67410.0	66579.0		

Table A1.3.1: Industry by Industry Flow Matrices 1935-1985

Table A1.3.1: Industry-by-Industry Flow Matrices 1935-1985 (Cont)

1984	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Final Demand	Total Output
Agriculture, Forestry and Fishing	2326.4	0.2	8782.2	5.9	327.7	30.2	3751.9	15224.6
Energy and Water Supply	618.8	17273.7	6856.9	619.3	4821.9	1257.3	29260.3	60708.2
Manufacture	4314.6	3011.7	48579.5	8738.2	13013.1	5104.7	102536.1	185297.9
Construction	79.5	1.6	247.0	8694.3	717.1	1237.7	31375.1	42352.2
Distribution, Transportation, and Communication	549.3	1858.3	12133.2	1338.6	9061.4	4495.3	70694.6	100130.8
Services	1316.4	2524.3	14617.9	5178.1	11808.5	12480.3	95386.6	143312.1
Value Added	6020.2	36038.4	94081.3	17777.6	60381.1	118706.5		
Total Input	15225.2	60708.2	185298.1	42352.0	100130.7	143312.0		
1985	**Agriculture**	**Energy**	**Manufacture**	**Construction**	**Distribution**	**Services**	**Final Demand**	**Total Output**
Agriculture, Forestry and Fishing	2650.6	0.3	8502.4	5.9	349.0	48.9	3979.8	15536.9
Energy and Water Supply	872.6	15567.0	7342.5	732.5	5381.9	1648.5	33360.9	64905.9
Manufacture	4325.3	3740.8	51605.6	8579.9	12895.8	4820.4	115209.6	201177.4
Construction	107.2	7.0	319.7	9249.4	742.7	1506.6	31662.1	43594.7
Distribution, Transportation, and Communication	361.8	1863.7	13333.6	1073.3	9595.6	6222.0	77145.9	109595.9
Services	1564.2	3730.8	17025.6	4757.3	12734.9	13899.7	105882.4	159594.9
Value Added	5655.1	39995.6	103048.6	19195.6	67896.2	131447.4		
Total Input	15536.8	64905.2	201178.0	43593.9	109596.1	159593.5		

Table A1.3.1: Industry by Industry Flow Matrices 1935-1985

Table A1.3.2: Supply-side Leontief Inverses 1935-1985						
1935	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Agriculture, Forestry and Fishing	1.04564	0.00336	0.29690	0.01349	0.01828	0.00543
Energy and Water Supply	0.01239	1.19741	0.32053	0.02099	0.12442	0.02317
Manufacture	0.03346	0.01602	1.45161	0.06541	0.05336	0.02209
Construction	0.00215	0.00152	0.01376	1.05453	0.07793	0.21636
Distribution, Transportation, etc	0.02712	0.01446	0.16303	0.02254	1.08134	0.03499
Services	0.00121	0.00240	0.00996	0.00849	0.01318	1.00813
Value Added	185.8	278.3	1970.0	276.6	1406.0	1178.9
Total Input	303.8	389.0	3248.8	470.6	1700.6	1348.5
1948	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Agriculture, Forestry and Fishing	1.03831	0.01186	0.82358	0.03054	0.01989	0.01156
Energy and Water Supply	0.02122	1.22758	0.59632	0.02898	0.10949	0.04483
Manufacture	0.02364	0.02216	1.54369	0.05716	0.03317	0.02166
Construction	0.01816	0.02790	0.15021	1.14867	0.06321	0.03756
Distribution, Transportation, etc	0.02750	0.02204	0.25076	0.02751	1.01038	0.00500
Services	0.01602	0.01500	0.15214	0.01617	0.00567	1.00338
Value Added	642.3	592.8	5821.6	692.5	2302.3	2856.2
Total Input	938.8	977.2	10985.2	1274.5	2656.9	3063.5
1950	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Agriculture, Forestry and Fishing	1.04855	0.01277	0.89643	0.03458	0.02390	0.01406
Energy and Water Supply	0.02991	1.16822	0.60350	0.03766	0.11790	0.06786
Manufacture	0.04203	0.02303	1.61983	0.06245	0.04153	0.02539
Construction	0.03057	0.02453	0.13884	1.15006	0.06916	0.04142
Distribution, Transportation, etc	0.02907	0.02786	0.31171	0.02756	1.01288	0.00687
Services	0.03162	0.02040	0.32650	0.04102	0.01406	1.00865
Value Added	655.0	657.3	6335.7	737.0	2716.7	1661.3
Total Input	1126.8	1049.8	12738.2	1433.7	3182.3	1939.5
1954	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Agriculture, Forestry and Fishing	1.04401	0.01060	0.79738	0.02898	0.02230	0.01810
Energy and Water Supply	0.03552	1.18856	0.61856	0.03157	0.13771	0.08489
Manufacture	0.04252	0.02326	1.75047	0.06362	0.04895	0.03974
Construction	0.02545	0.02093	0.11199	1.14872	0.04749	0.02185
Distribution, Transportation, etc	0.03390	0.03210	0.44093	0.03401	1.01782	0.01219
Services	0.01830	0.01356	0.23264	0.02484	0.00959	1.00711
Value Added	703.2	930.6	8932.9	943.2	3447.5	4603.7
Total Input	1372.1	1514.2	19469.8	1933.2	4179.0	5145.7

Table A1.3.2: Supply-side Leontief Inverses 1935-1985

Table A1.3.2: Supply-side Leontief Inverses 1935-1985 (Cont)						
1963	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.17828	0.00823	0.43097	0.02389	0.01946	0.02005
Energy and Water Supply	0.02838	1.21046	0.53628	0.03888	0.09943	0.06893
Manufacture	0.04350	0.02880	1.60886	0.08872	0.06226	0.05266
Construction	0.01336	0.00992	0.06310	1.20650	0.02985	0.01392
Distribution, Transportation, etc	0.03110	0.02308	0.32492	0.03431	1.11012	0.03852
Services	0.01786	0.01160	0.20175	0.02645	0.05230	1.03520
Value Added	843.2	1587.9	12229.0	1901.9	6347.1	8443.5
Total Input	1944.2	2544.5	24775.5	3902.5	8480.0	9782.0
1968	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.25692	0.01266	0.72944	0.04571	0.02497	0.02992
Energy and Water Supply	0.03649	1.23142	0.52929	0.04989	0.10204	0.06621
Manufacture	0.04549	0.02618	1.59935	0.09995	0.04739	0.05355
Construction	0.01322	0.01718	0.06861	1.19669	0.01297	0.00893
Distribution, Transportation, etc	0.02065	0.04148	0.28297	0.03253	1.10716	0.04558
Services	0.01151	0.01713	0.19983	0.02552	0.02928	1.03496
Value Added	1035.5	2677.1	16431.8	2904.3	8566.0	12844.2
Total Input	2509.8	4365.3	33642.4	5905.3	10975.4	14797.7
1970	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.25270	0.01260	0.70814	0.04001	0.02280	0.03243
Energy and Water Supply	0.03689	1.20277	0.55661	0.04787	0.10070	0.07079
Manufacture	0.04332	0.02722	1.62901	0.09180	0.04501	0.06295
Construction	0.01414	0.03073	0.08865	1.17399	0.01320	0.01347
Distribution, Transportation, etc	0.02006	0.03875	0.33854	0.03417	1.09944	0.05736
Services	0.01200	0.01755	0.22470	0.02373	0.02425	1.03961
Value Added	1202.5	2836.7	19578.5	3202.2	10169.3	15811.2
Total Input	2898.1	4730.0	41603.4	6463.1	12800.6	18536.3
1971	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.28420	0.01134	0.77673	0.04682	0.02880	0.03228
Energy and Water Supply	0.03723	1.20529	0.51759	0.04865	0.11512	0.06293
Manufacture	0.04167	0.02100	1.58058	0.09502	0.05170	0.05571
Construction	0.01356	0.03035	0.07713	1.16032	0.01408	0.01050
Distribution, Transportation, etc	0.02222	0.03678	0.33355	0.03709	1.11868	0.05285
Services	0.01327	0.01704	0.23495	0.02747	0.03110	1.03884
Value Added	1278.9	3370.5	20757.8	3493.2	11365.7	18774.9
Total Input	3181.8	5356.9	44018.8	7186.9	14845.7	21551.2

Table A1.3.2: Supply-side Leontief Inverses 1935-1985

Table A1.3.2: Supply-side Leontief Inverses 1935-1985 (Cont)						
1972	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.30364	0.01361	0.79571	0.04637	0.02772	0.04529
Energy and Water Supply	0.03877	1.21626	0.50910	0.04682	0.10702	0.06765
Manufacture	0.04111	0.02444	1.56349	0.09078	0.04774	0.06637
Construction	0.01185	0.02810	0.06049	1.12243	0.01089	0.01094
Distribution, Transportation, etc	0.02295	0.03147	0.32674	0.03426	1.11368	0.05915
Services	0.01151	0.01540	0.19914	0.02232	0.02573	1.04449
Value Added	1565.5	3614.7	22788.4	4331.3	12678.6	20876.5
Total Input	3700.4	5816.9	47277.3	8072.3	16222.4	24430.6
1973	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.28949	0.01536	0.66410	0.05067	0.02508	0.04739
Energy and Water Supply	0.03733	1.15144	0.41468	0.05163	0.10179	0.07140
Manufacture	0.04489	0.02809	1.29319	0.09823	0.04294	0.06884
Construction	0.01573	0.02268	0.04335	1.25384	0.00842	0.00965
Distribution, Transportation, etc	0.02138	0.03209	0.27414	0.03936	1.08522	0.06810
Services	0.01349	0.01832	0.18093	0.02794	0.02973	1.04559
Value Added	1874.6	4038.4	27770.0	5634.8	14745.2	24049.7
Total Input	4542.9	6500.6	47469.4	11348.7	18414.7	28493.7
1974	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.29363	0.01420	0.75848	0.05225	0.08406	0.02947
Energy and Water Supply	0.03080	1.22204	0.53221	0.05154	0.15155	0.05733
Manufacture	0.04401	0.02685	1.55236	0.10495	0.08966	0.04728
Construction	0.01678	0.02950	0.06900	1.29129	0.03039	0.04134
Distribution, Transportation, etc	0.02247	0.03201	0.28193	0.03798	1.14788	0.05451
Services	0.01795	0.03084	0.21164	0.02146	0.08826	1.11267
Value Added	2016.4	7067.0	33493.6	6673.4	18748.0	26708.2
Total Input	5312.7	11184.8	68683.2	13887.2	28323.9	33063.6
1979	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.24865	0.02318	1.10929	0.06213	0.09932	0.02783
Energy and Water Supply	0.03115	1.28673	0.41268	0.03487	0.15138	0.02572
Manufacture	0.03785	0.02995	1.46565	0.08050	0.10482	0.03559
Construction	0.00788	0.05149	0.05740	1.29911	0.04387	0.05382
Distribution, Transportation, etc	0.02303	0.03312	0.30266	0.05061	1.13527	0.05585
Services	0.01843	0.01576	0.20312	0.01976	0.09807	1.04837
Value Added	4149.0	20013.0	69096.0	13215.0	44488.0	57512.0
Total Input	10608.0	30977.0	140037.0	27073.0	67410.0	66579.0

Table A1.3.2: Supply-side Leontief Inverses 1935-1985

Table A1.3.2: Supply-side Leontief Inverses 1935-1985 (Cont)						
1984	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.20872	0.02600	0.97320	0.06235	0.11081	0.04003
Energy and Water Supply	0.02588	1.40885	0.26748	0.03870	0.14943	0.04868
Manufacture	0.04104	0.03670	1.42076	0.08921	0.12030	0.05257
Construction	0.00415	0.00244	0.02434	1.26223	0.02955	0.04266
Distribution, Transportation, etc	0.01427	0.03555	0.21053	0.03479	1.12561	0.06366
Services	0.01870	0.03485	0.19366	0.06444	0.12020	1.11004
Value Added	6020.2	36038.4	94081.3	17777.6	60381.1	118706.5
Total Input	15225.4	60708.3	185298.8	42352.0	100130.8	143312.0
1985	Agriculture	Energy	Manufacture	Constructior	Distribution	Services
Agriculture, Forestry and Fishing	1.23132	0.02633	0.93308	0.05419	0.10258	0.03790
Energy and Water Supply	0.02945	1.32667	0.25533	0.03669	0.14464	0.05410
Manufacture	0.03826	0.03828	1.40446	0.07976	0.10876	0.04784
Construction	0.00531	0.00324	0.02930	1.27325	0.03072	0.05099
Distribution, Transportation, etc	0.01138	0.03255	0.20815	0.02860	1.12110	0.07721
Services	0.01961	0.04168	0.19983	0.05492	0.11651	1.11120
Value Added	5655.1	39995.6	103048.6	19195.6	67896.2	131447.4
Total Input	15536.7	64904.9	201177.7	43593.6	109595.9	159593.3

Table A1.3.2: Supply-side Leontief Inverses 1935-1985

A1.3.2: Leontief inverse

Table:

Table A1.3.2: Supply-side Leontief inverses for 1935-85

Notes:

The tables, as presented in Table A3.2.2, were used to synthesize direct inputs and outputs into total inputs and outputs.

A1.3.3: Eigenprices

Tables:

Table A1.3.3/85: Computation of eigenprices for 1985
Table A1.3.4: Eigenprices for 1935-90

Notes:

Table A1.3.3/85 is presented as an example of the approach used in the derivation of eigenprices for 1985. The same methodology was used for all other tables.

The eigenprices calculated for the six industrial groupings and four primary inputs for the tables from 1935 to 1990 are presented in Table A1.3.4.

Table A1.3.3/85: Computation of Eigenprices for 1985													
	Agricult	Energy	Manufact	Construct	Distrib	Services		Consumpt	Govm't	Invest	Exports		Total
Agriculture, Forestry, and Fishing	2651	0	8502	6	349	49		2385	133	132	1330		15537
Energy	873	15567	7343	733	5382	1649		12082	2506	468	18306		64906
Manufacturing	4325	3741	51606	8580	12896	4820		34477	10041	14849	55842		201177
Construction	107	7	320	9249	743	1507		1515	2640	27405	102		43595
Distribution, Transportation etc	362	1864	13334	1073	9596	6222		56242	4229	1961	14715		109596
Services	1564	3731	17026	4757	12735	13900		44200	50389	3082	8211		159595
									Value added				
Imports	1136	10298	31877	1853	5286	1510			51959				594406
Sales by final demand	25	69	2036	193	382	115			2820				
Wages	1776	7645	53179	9380	41224	81370			194574				
Profits	3288	22698	13021	7315	17523	45790			109635				
Taxes - subsidies	-569	-714	2936	454	3481	2662		V	51959	0	0	0	
									0	2820	0	0	
Total	15537	64906	201177	43595	109596	159595			0	0	194574	0	
									0	0	0	109635	
(I-A)	0.8294	0.0000	-0.0423	-0.0001	-0.0032	-0.0003							
	-0.0562	0.7602	-0.0365	-0.0168	-0.0491	-0.0103		V inverse	1.92E-05	0	0	0	
	-0.2784	-0.0576	0.7435	-0.1968	-0.1177	-0.0302			0	0.000355	0	0	
	-0.0069	-0.0001	-0.0016	0.7878	-0.0068	-0.0094			0	0	5.14E-06	0	
	-0.0233	-0.0287	-0.0663	-0.0246	0.9124	-0.0390			0	0	0	9.12E-06	
	-0.1007	-0.0575	-0.0846	-0.1091	-0.1162	0.9129							
									Final demand				Total
Inverse (I-A)	1.2313	0.0063	0.0721	0.0193	0.0145	0.0037			3980				15537
	0.1230	1.3267	0.0824	0.0546	0.0857	0.0220			33361				64906
Inverse Leontief	0.4954	0.1186	1.4045	0.3681	0.1996	0.0603			115210				201177
(Demand side)	0.0149	0.0022	0.0064	1.2733	0.0122	0.0139			31662				43595
	0.0803	0.0550	0.1134	0.0719	1.1211	0.0530			77146				109596
	0.2015	0.1025	0.1585	0.2010	0.1697	1.1112			105882				159595
Q	0.0731	0.1587	0.1585	0.0425	0.0482	0.0095							
Primary input	0.0016	0.0011	0.0101	0.0044	0.0035	0.0007							
factor coefficients	0.1143	0.1178	0.2643	0.2152	0.3761	0.5099							
	0.2116	0.3497	0.0647	0.1678	0.1599	0.2869							

Table A1.3.3/85: Computation of Eigenprices for 1985

Table A1.3.3/85: Computation of Eigenprices for 1985 (Cont)						
L	0.1945	0.2335	0.2481	0.1279	0.1025	0.0270
Cost matrix in terms	0.0076	0.0029	0.0150	0.0099	0.0062	0.0017
of one factor	0.4223	0.2617	0.5140	0.5094	0.5754	0.6084
	0.4088	0.5115	0.1996	0.3298	0.2759	0.3420
(I-B)	0.8294	0.0000	-0.5472	-0.0004	-0.0225	-0.0031
	-0.0134	0.7602	-0.1131	-0.0113	-0.0829	-0.0254
	-0.0215	-0.0186	0.7435	-0.0426	-0.0641	-0.0240
	-0.0025	-0.0002	-0.0073	0.7878	-0.0170	-0.0346
	-0.0033	-0.0170	-0.1217	-0.0098	0.9124	-0.0568
	-0.0098	-0.0234	-0.1067	-0.0298	-0.0798	0.9129
Inverse (I-B)	1.2313	0.0263	0.9331	0.0542	0.1026	0.0379
	0.0294	1.3267	0.2553	0.0367	0.1446	0.0541
Inverse Leontief	0.0383	0.0383	1.4045	0.0798	0.1088	0.0478
(Supply side)	0.0053	0.0032	0.0293	1.2733	0.0307	0.0510
	0.0114	0.0326	0.2081	0.0286	1.1211	0.0772
	0.0196	0.0417	0.1998	0.0549	0.1165	1.1112
w	6224	40709	100113	18741	64415	128785
Value added	5655	39996	103049	19196	67896	131447
Total inputs	15537	64905	201178	43594	109596	159593
R	0.0219	0.1982	0.6135	0.0357	0.1017	0.0291
Primary input	0.0087	0.0244	0.7220	0.0686	0.1354	0.0409
factor quotas	0.0091	0.0393	0.2733	0.0482	0.2119	0.4182
	0.0300	0.2070	0.1188	0.0667	0.1598	0.4177
y'	3980	33361	115210	31662	77146	105882
m	0.2562	0	0	0	0	0
Diagonal matrix	0	0.5140	0	0	0	0
of final use quotas	0	0	0.5727	0	0	0
	0	0	0	0.7263	0	0
	0	0	0	0	0.7039	0
	0	0	0	0	0	0.6634

Table A1.3.3/85: Computation of Eigenprices for 1985

Table A1.3.3/85: Computation of Eigenprices for 1985 (Cont)													
B'	1.2313	0.0294	0.0383	0.0053	0.0114	0.0196							
Transpose of	0.0263	1.3267	0.0383	0.0032	0.0326	0.0417							
Leontief inverse	0.9331	0.2553	1.4045	0.0293	0.2081	0.1998							
(Supply side)	0.0542	0.0367	0.0798	1.2733	0.0286	0.0549							
	0.1026	0.1446	0.1088	0.0307	1.1211	0.1165							
	0.0379	0.0541	0.0478	0.0510	0.0772	1.1112							
										N = yL' V(-1)			
mB'	0.3154	0.0075	0.0098	0.0014	0.0029	0.0050		N	0.01489	0.01069	0.00864	0.01484	
	0.0135	0.6819	0.0197	0.0017	0.0167	0.0214		Factor	0.14989	0.03424	0.04488	0.15565	
	0.5344	0.1462	0.8043	0.0168	0.1192	0.1144		norm	0.55015	0.61087	0.30437	0.20979	
	0.0394	0.0266	0.0579	0.9247	0.0208	0.0399		matrix	0.07793	0.11067	0.08290	0.09525	
	0.0722	0.1018	0.0766	0.0216	0.7892	0.0820			0.15216	0.17009	0.22812	0.19417	
	0.0251	0.0359	0.0317	0.0338	0.0512	0.7372			0.05498	0.06343	0.33110	0.33030	
R'	0.0219	0.0087	0.0091	0.0300	N	0.0149	0.0107	0.0086	0.0148				
Transpose of	0.1982	0.0244	0.0393	0.2070	Factor	0.1499	0.0342	0.0449	0.1556		N = mB' R'		
primary input	0.6135	0.7220	0.2733	0.1188	norm	0.5501	0.6109	0.3044	0.2098				
factor quotas	0.0357	0.0686	0.0482	0.0667	matrix	0.0779	0.1107	0.0829	0.0953				
	0.1017	0.1354	0.2119	0.1598		0.1522	0.1701	0.2281	0.1942				
	0.0291	0.0409	0.4182	0.4177		0.0550	0.0634	0.3311	0.3303				
y	3980	0	0	0	0	0		L'	0.1945	0.0076	0.4223	0.4088	
Diagonal matrix	0	33361	0	0	0	0		Transpose	0.2335	0.0029	0.2617	0.5115	
of final uses	0	0	115210	0	0	0		of cost	0.2481	0.0150	0.5140	0.1996	
	0	0	0	31662	0	0		matrix	0.1279	0.0099	0.5094	0.3298	
	0	0	0	0	77146	0			0.1025	0.0062	0.5754	0.2759	
	0	0	0	0	0	105882			0.0270	0.0017	0.6084	0.3420	

Table A1.3.3/85: Computation of Eigenprices for 1985

Table A1.3.3/85: Computation of Eigenprices for 1985 (Cont)												
F = LN	0.2014	0.1949	0.1306	0.1323				yL'	774	30	1681	1627
Cost norm	0.0106	0.0116	0.0075	0.0064					7788	97	8732	17064
matrix	0.4890	0.5203	0.5468	0.5161					28585	1723	59222	23000
	0.2791	0.2490	0.2908	0.3255					4049	312	16130	10443
									7906	480	44386	21287
P = NL	0.0127	0.0134	0.0113	0.0113	0.0107	0.010751			2857	179	64423	36213
Norm cost	0.1120	0.1265	0.0918	0.0937	0.0843	0.0846						
matrix	0.3259	0.3172	0.3440	0.3006	0.2932	0.2728						
	0.0899	0.0889	0.0826	0.0847	0.0827	0.0853						
	0.2066	0.1950	0.1963	0.2014	0.2015	0.2096						
	0.2860	0.2686	0.2507	0.2853	0.2877	0.3160						
	Imports	Sales by fd	Wages	Profits		Agricult	Energy	Manufact	Construct	Distrib	Services	
Computation	1.0000	1.0000	1.0000	1.0000		1.0332	1.0096	0.9767	0.9770	0.9600	0.9791	
by Iteration	0.9801	0.9758	0.9757	0.9803		1.0108	0.9884	0.9550	0.9553	0.9384	0.9570	
	0.9584	0.9541	0.9539	0.9585		0.9883	0.9665	0.9338	0.9341	0.9175	0.9357	
	0.9371	0.9328	0.9326	0.9372		0.9663	0.9449	0.9130	0.9133	0.8970	0.9148	
	0.9162	0.9121	0.9119	0.9163		0.9448	0.9239	0.8926	0.8929	0.8771	0.8945	
	0.8958	0.8918	0.8916	0.8959		0.9237	0.9033	0.8728	0.8730	0.8575	0.8745	
	0.8759	0.8719	0.8717	0.8759		0.9032	0.8832	0.8533	0.8536	0.8384	0.8551	
	0.8564	0.8525	0.8523	0.8564		0.8830	0.8635	0.8343	0.8346	0.8198	0.8360	
	0.8373	0.8335	0.8333	0.8373		0.8634	0.8443	0.8157	0.8160	0.8015	0.8174	
	0.8187	0.8149	0.8148	0.8187		0.8442	0.8255	0.7976	0.7978	0.7836	0.7992	
	0.8004	0.7968	0.7966	0.8005		0.8254	0.8071	0.7798	0.7801	0.7662	0.7814	
Eigenyield	2.28%	97.77%										
	286596	359062.5	367240.7									
	0.780404	0.798178										
Eigenprices	1.002834	0.998256	0.998034	1.002868		1.057597	1.034235	0.999233	0.999559	0.981796	1.001277	

Table A1.3.3/85: Computation of Eigenprices for 1985

Table A1.3.3/85: Computation of Eigenprices for 1985 (Cont)

Input-output Tables scaled into Eigenprices

	Agricult	Energy	Manufact	Construct	Distrib	Services		Consumpt	Govm't	Invest	Exports		Total
Agriculture	2803	0	8992	6	369	52		2523	140	140	1407		16432
Energy	902	16100	7594	758	5566	1705		12496	2591	484	18933		67128
Manufacturing	4322	3738	51566	8573	12886	4817		34451	10034	14838	55799		201023
Construction	107	7	320	9245	742	1506		1514	2639	27393	102		43575
Distribution	355	1830	13091	1054	9421	6109		55218	4152	1925	14447		107601
Services	1566	3736	17047	4763	12751	13917		44257	50454	3086	8222		159799
Imports	1139	10327	31967	1858	5301	1514			52106				595558
Sales by final demand	24	69	2033	193	381	115			2815				
Wages	1773	7630	53074	9362	41143	81210			194191				
Profits	3297	22763	13059	7336	17573	45921			109950				367241
Residual surplus	142	929	2281	427	1467	2933			8178				
Total	16432	67128	201023	43575	107601	159799			595558				
Surplus	2.28%	2.28%	2.28%	2.28%	2.28%	2.28%			2.28%				

Table A1.3.3/85: Computation of Eigenprices for 1985

Table 1.3.4A: Eigenprices 1935-90

	1935	1948	1950	1954	1963	1968	1970	1971	1972	1973	1974	1979	1984	1985
Agriculture, Forestry, and Fishing	1.0858	1.1056	1.0964	1.1698	1.1608	1.1261	1.1012	1.1163	1.0764	1.0715	1.0756	1.0502	1.0631	1.0576
Energy and Water Supply	1.1001	1.0305	1.0369	1.0233	0.9791	0.9961	0.9930	0.9908	1.0240	1.0365	1.0451	1.0128	1.0474	1.0342
Manufacturing	0.9835	0.9685	0.9767	0.9767	0.9966	1.0078	1.0091	1.0064	1.0032	0.9990	0.9979	0.9998	0.9977	0.9992
Construction	1.0430	1.0381	1.0421	1.0262	0.9908	0.9739	0.9687	0.9762	0.9837	0.9896	0.9988	1.0023	0.9980	0.9996
Distribution	1.0173	1.0082	1.0210	0.9876	0.9857	0.9857	0.9806	0.9823	0.9895	0.9935	0.9929	0.9880	0.9814	0.9818
Services	0.9654	1.0340	1.0017	1.0185	0.9978	0.9971	1.0010	1.0021	0.9986	0.9983	0.9935	1.0040	0.9999	1.0013
Imports	0.9977	0.9836	0.9909	0.9923	1.0024	1.0032	1.0023	1.0009	1.0021	1.0017	1.0044	1.0003	1.0034	1.0028
Sales by final demand	0.9961	0.9757	0.9962	0.9857	1.0002	1.0025	1.0026	1.0012	1.0008	0.9997	1.0002	0.9998	0.9974	0.9983
Wages	1.0008	1.0034	1.0019	1.0022	0.9991	0.9991	0.9995	0.9997	0.9995	0.9992	0.9985	0.9996	0.9971	0.9980
Profits	1.0047	1.0039	1.0043	1.0042	1.0047	1.0024	1.0015	1.0017	1.0008	1.0013	1.0010	1.0009	1.0048	1.0029
Residual surplus	9.64%	8.28%	9.17%	7.43%	2.16%	3.63%	4.31%	3.88%	3.23%	2.51%	1.58%	3.13%	2.20%	2.28%

Table 1.3.4B: Underpricing (Overpricing) 1935-90

	1935	1948	1950	1954	1963	1968	1970	1971	1972	1973	1974	1979	1984	1985
Agriculture, Forestry, and Fishing	8.58%	10.56%	9.64%	16.98%	16.08%	12.61%	10.12%	11.63%	7.64%	7.15%	7.56%	5.02%	6.31%	5.76%
Energy and Water Supply	10.01%	3.05%	3.69%	2.33%	-2.09%	-0.39%	-0.70%	-0.92%	2.40%	3.65%	4.51%	1.28%	4.74%	3.42%
Manufacturing	-1.65%	-3.15%	-2.33%	-2.33%	-0.34%	0.78%	0.91%	0.64%	0.32%	-0.10%	-0.21%	-0.02%	-0.23%	-0.08%
Construction	4.30%	3.81%	4.21%	2.62%	-0.92%	-2.61%	-3.13%	-2.38%	-1.63%	-1.04%	-0.12%	0.23%	-0.20%	-0.04%
Distribution	1.73%	0.82%	2.10%	-1.24%	-1.43%	-1.43%	-1.94%	-1.77%	-1.05%	-0.65%	-0.71%	-1.20%	-1.86%	-1.82%
Services	-3.46%	3.40%	0.17%	1.85%	-0.22%	-0.29%	0.10%	0.21%	-0.14%	-0.17%	-0.65%	0.40%	-0.01%	0.13%
Imports	-0.23%	-1.64%	-0.91%	-0.77%	0.24%	0.32%	0.23%	0.09%	0.21%	0.17%	0.44%	0.03%	0.34%	0.28%
Sales by final demand	-0.39%	-2.43%	-0.38%	-1.43%	0.02%	0.25%	0.26%	0.12%	0.08%	-0.03%	0.02%	-0.02%	-0.26%	-0.17%
Wages	0.08%	0.34%	0.19%	0.22%	-0.09%	-0.09%	-0.05%	-0.03%	-0.05%	-0.08%	-0.15%	-0.04%	-0.29%	-0.20%
Profits	0.47%	0.39%	0.43%	0.42%	0.47%	0.24%	0.15%	0.17%	0.08%	0.13%	0.10%	0.09%	0.48%	0.29%

Table 1.3.4: Eigenprices 1935-1985

APPENDIX NO 2:

DERIVATION OF THE CAPITAL MATRIX

Beer barrels and blast furnaces, harbour installations and hotel-room furniture are not capital by virtue of their physical properties but by virtue of their economic functions.

Ludwig M. Lachmann

A.2.1: Total Investment and capital

Tables:

Table A2.1A: Total Investment 1948-61
Table A2.1B: Total Investment 1962-76
Table A2.1C: Total Investment 1977-90

Notes:

Total capital vector calculated using the capital stock total divided by assett type taken from Feinstein (1972) as the starting point. The Plant and Equipment investment total was subdivided using the proportions in Table A2.6 and initial capital total disaggregated to give the maximum stability in the growth of the capital vector.

The depreciation figures cited in Table 8.2.2 were estimated so as to minimize fluctuations in the capital growth and average ages. The price deflators, by capital asset type, used are included in Table A2.5 below.

A.2.2: Investment and capital by industrial group

Tables:

Table A2.2.1A: Investment for Agriculture, Forestry, and Fishing 1948-61
Table A2.2.1B: Investment for Agriculture, Forestry, and Fishing 1962-76
Table A2.2.1C: Investment for Agriculture, Forestry, and Fishing 1977-90

Table A2.2.2A: Investment for Energy and Water Supply 1948-61
Table A2.2.2B: Investment for Energy and Water Supply 1962-76
Table A2.2.2C: Investment for Energy and Water Supply 1977-90

Table A2.2.3A: Investment for Manufacturing 1948-61
Table A2.2.3B: Investment for Manufacturing 1962-76
Table A2.2.3C: Investment for Manufacturing 1977-90

Table A2.2.4A: Investment for Construction 1948-61
Table A2.2.4B: Investment for Construction 1962-76
Table A2.2.4C: Investment for Construction 1977-90

Table A2.1A: Total Capital 1947-1961

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Investment (£M)															
Real Estate		293	366	411	450	512	548	604	718	851	935	1003	1060	1166	1364
Dwellings		337	332	331	376	494	630	645	640	634	616	586	661	750	791
Road Vehicles		129	152	149	156	168	170	183	210	219	211	249	276	325	344
Railway		28	29	31	33	27	36	47	55	65	89	85	96	92	81
Ships		86	80	74	59	57	91	91	84	115	151	159	175	178	144
Aircraft		8	12	8	7	8	10	10	19	27	46	36	25	43	33
Metal Goods		140	160	188	220	235	248	274	313	344	383	392	409	442	519
Plant		91	96	107	123	125	127	144	159	162	189	204	211	220	254
Mech. Engineering		142	164	193	234	243	245	268	302	352	399	403	401	454	548
Elec. Engineering		117	130	150	170	186	207	233	273	282	307	322	361	376	428
Total		1370	1521	1642	1828	2056	2312	2499	2773	3051	3327	3439	3675	4046	4506
Capital Stock (£M)															
Real Estate	8017	8300	8507	8742	10064	11329	11722	12084	13383	14437	15657	16822	17254	18097	19311
Dwellings	8675	9100	9399	9790	11617	13113	13344	13711	15027	16256	16982	17535	18184	18923	20041
Road Vehicles	535	542	589	709	747	836	804	815	855	959	1006	1065	1105	1183	1306
Railway	153	157	166	182	186	209	236	253	275	310	382	422	462	490	504
Ships	639	666	695	744	722	803	907	930	940	1001	1154	1236	1311	1373	1398
Aircraft	42	43	50	53	52	59	66	68	78	96	137	157	161	182	190
Metal Goods	1661	1743	1848	1990	2256	2605	2809	2949	3252	3615	3942	4239	4462	4718	5148
Plant	323	337	371	412	477	547	580	609	670	730	795	857	901	948	1037
Mech. Engineering	1196	1253	1339	1458	1678	1950	2102	2206	2431	2719	2992	3231	3392	3602	3971
Elec. Engineering	1595	1659	1736	1844	2056	2346	2513	2626	2890	3190	3447	3686	3884	4099	4450
Total	22837	23800	24700	25925	29857	33797	35085	36252	39801	43313	46495	49249	51117	53615	57355

Table A2.1: Total Capital Investment

Table A2.1A: Total Capital 1947-1961 (Cont)

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Capital Growth (%)															
Real Estate		1.6%	2.4%	2.8%	2.6%	2.6%	2.8%	3.2%	3.6%	4.1%	4.2%	4.2%	4.4%	4.7%	5.4%
Dwellings		2.8%	2.6%	2.5%	2.3%	2.9%	3.9%	3.9%	3.4%	3.0%	2.7%	2.4%	2.7%	3.1%	3.1%
Road Vehicles		5.0%	7.8%	1.3%	1.1%	0.1%	1.5%	3.2%	6.1%	3.7%	1.2%	4.4%	6.6%	10.3%	8.6%
Railway		3.5%	4.9%	-7.6%	-1.9%	0.3%	19.5%	9.1%	9.8%	4.0%	19.1%	8.9%	12.6%	9.2%	1.1%
Ships		3.4%	3.6%	-9.8%	-6.9%	-0.4%	19.2%	4.3%	2.2%	-1.7%	11.3%	5.6%	9.0%	7.9%	0.1%
Aircraft		4.2%	14.0%	-9.8%	-6.7%	1.1%	19.3%	4.2%	16.2%	14.1%	37.4%	12.8%	5.6%	16.2%	2.7%
Metal Goods		3.3%	4.0%	4.9%	5.3%	4.4%	4.2%	4.7%	5.1%	5.0%	5.2%	4.7%	4.6%	4.8%	5.6%
Plant		9.4%	8.0%	8.0%	7.6%	3.7%	2.4%	4.7%	5.0%	2.9%	5.0%	5.0%	4.5%	4.3%	6.0%
Mech. Engineering		3.7%	4.8%	6.1%	6.9%	5.1%	4.2%	4.7%	5.0%	5.7%	6.2%	5.1%	4.3%	5.3%	6.7%
Elec. Engineering		2.2%	2.7%	3.4%	3.6%	3.2%	3.5%	4.3%	4.9%	4.2%	4.3%	4.1%	4.7%	4.6%	5.1%
Average Age (Years)															
Real Estate	27.3	27.3	27.1	26.8	26.5	26.3	26.0	25.7	25.2	24.7	24.2	23.7	23.1	22.6	21.9
Dwellings	26.0	26.0	26.0	26.1	26.3	26.2	25.9	25.7	25.5	25.5	25.5	25.7	25.7	25.6	25.6
Road Vehicles	3.2	3.2	3.1	3.3	3.4	3.5	3.5	3.5	3.4	3.4	3.5	3.4	3.3	3.1	3.0
Railway	4.4	4.4	4.4	5.0	5.2	5.2	4.4	4.2	4.0	4.1	3.7	3.6	3.5	3.5	3.8
Ships	6.8	6.8	6.8	7.7	8.5	8.5	7.2	7.1	7.1	7.4	6.8	6.7	6.3	6.1	6.4
Aircraft	3.5	3.7	3.5	4.2	4.7	4.8	4.2	4.2	3.8	3.6	2.8	2.9	3.1	3.0	3.3
Metal Goods	11.5	11.5	11.4	11.2	11.0	10.9	10.9	10.8	10.7	10.5	10.4	10.4	10.3	10.3	10.1
Plant	2.7	2.7	2.8	2.8	2.8	2.9	3.1	3.1	3.1	3.2	3.2	3.2	3.2	3.2	3.2
Mech. Engineering	7.8	7.8	7.8	7.6	7.4	7.4	7.4	7.4	7.3	7.2	7.1	7.1	7.2	7.1	7.0
Elec. Engineering	13.2	13.2	13.1	13.0	12.8	12.7	12.6	12.4	12.1	12.0	11.8	11.7	11.5	11.4	11.2

Table A2.1: Total Capital Investment

Table A2.1B: Total Capital 1962-1976

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Investment (£M)															
Real Estate	1485	1500	1789	1930	2036	2252	2476	2622	2616	3249	3639	4575	5729	7020	7716
Dwellings	856	914	1217	1286	1374	1525	1675	1667	1643	1898	2254	3153	3786	4682	5450
Road Vehicles	311	344	403	427	435	444	487	534	581	633	759	883	1070	1187	1594
Railway	66	48	41	48	34	25	30	17	21	16	29	39	47	59	57
Ships	116	92	130	106	77	135	210	259	275	339	483	626	580	639	433
Aircraft	21	28	41	40	19	37	86	44	98	115	93	79	89	104	191
Metal Goods	535	566	650	727	814	850	854	927	1073	1174	1240	1501	1822	2141	2670
Plant	248	274	322	352	370	393	416	423	478	494	517	642	729	893	1173
Mech. Engineering	552	542	630	719	784	816	869	968	1108	1153	1055	1246	1501	1799	2197
Elec. Engineering	458	527	607	664	741	802	829	851	968	1086	1212	1490	1650	1885	2307
Total	4648	4835	5830	6299	6684	7279	7932	8312	8861	10156	11281	14234	17002	20410	23788
Capital Stock (£M)															
Real Estate	21210	23092	25098	27248	29812	31360	34720	37968	42464	48904	57637	73195	100058	127546	145062
Dwellings	21211	23064	24693	26151	28259	29426	32221	34877	38644	43489	49614	65669	86698	108294	126397
Road Vehicles	1364	1386	1519	1669	1777	1895	2050	2257	2493	2842	3149	3617	4472	6016	7336
Railway	485	458	438	430	409	381	363	355	343	329	339	349	387	436	489
Ships	1346	1298	1320	1326	1302	1333	1444	1685	1892	2166	2646	3185	3864	4632	5292
Aircraft	179	179	196	211	203	214	273	299	369	451	518	553	627	716	900
Metal Goods	5560	5908	6389	7050	7777	8264	8959	9794	11164	12785	14148	15979	18984	24318	30330
Plant	1101	1164	1274	1414	1547	1635	1766	1895	2122	2352	2517	2811	3271	4111	5111
Mech. Engineering	4306	4548	4909	5423	5972	6330	6881	7563	8654	9869	10704	11854	13830	17445	21413
Elec. Engineering	4802	5140	5600	6205	6870	7352	8040	8808	10042	11531	12854	14644	17377	22185	27541
Total	61561	66238	71435	77128	83927	88190	96716	105501	118186	134720	154126	191855	249568	315700	369871

Table A2.1: Total Capital Investment

Table A2.1B: Total Capital 1962-1976 (Cont)

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Capital Growth (%)															
Real Estate	5.4%	4.8%	5.5%	5.5%	5.2%	5.6%	5.5%	5.3%	4.4%	5.0%	4.6%	4.5%	4.0%	3.7%	3.5%
Dwellings	3.2%	3.1%	4.1%	4.1%	4.1%	4.4%	4.4%	4.0%	3.4%	3.5%	3.7%	4.0%	3.5%	3.5%	3.5%
Road Vehicles	3.6%	6.4%	8.9%	7.5%	5.9%	4.5%	4.9%	4.8%	4.3%	2.9%	5.4%	5.8%	5.2%	-0.3%	2.2%
Railway	-4.5%	-1.1%	-5.0%	-3.9%	-5.4%	-8.8%	-7.3%	-10.7%	-9.5%	-10.7%	-7.1%	-4.3%	-3.2%	-1.7%	-3.8%
Ships	-4.4%	0.9%	1.1%	-1.7%	-2.3%	0.4%	5.3%	6.3%	5.3%	6.7%	10.1%	12.0%	5.9%	4.4%	-2.0%
Aircraft	-6.5%	4.9%	8.8%	5.3%	-4.3%	3.0%	24.1%	-0.3%	15.8%	14.1%	3.6%	-0.8%	-0.9%	-0.6%	7.9%
Metal Goods	5.1%	5.1%	5.8%	5.9%	6.1%	5.9%	5.0%	4.9%	5.1%	4.6%	4.1%	4.9%	5.1%	4.2%	4.2%
Plant	3.3%	4.6%	7.0%	6.6%	5.2%	5.3%	4.7%	3.0%	3.2%	1.2%	0.7%	3.7%	2.9%	2.2%	3.8%
Mech. Engineering	5.5%	4.5%	5.6%	6.1%	5.9%	5.6%	5.3%	5.5%	5.5%	4.2%	2.1%	2.8%	3.2%	2.6%	2.5%
Elec. Engineering	5.0%	5.9%	6.5%	6.4%	6.5%	6.6%	5.9%	5.2%	5.1%	4.9%	4.9%	5.8%	5.0%	3.8%	3.7%
Average Age (Years)															
Real Estate	21.3	20.9	20.3	19.8	19.4	18.9	18.5	18.1	18.0	17.7	17.5	17.4	17.3	17.3	17.3
Dwellings	25.5	25.5	25.2	24.9	24.6	24.3	24.0	23.8	23.7	23.6	23.5	23.3	23.3	23.2	23.2
Road Vehicles	3.1	3.1	3.0	3.0	3.0	3.1	3.1	3.1	3.2	3.2	3.2	3.2	3.2	3.4	3.4
Railway	4.3	4.5	4.9	5.3	5.6	6.2	6.6	7.2	7.7	8.3	8.5	8.4	8.3	8.0	8.0
Ships	7.0	7.1	7.2	7.5	7.8	7.9	7.6	7.3	7.1	6.8	6.4	5.9	5.9	6.0	6.4
Aircraft	3.9	4.0	3.9	4.0	4.4	4.5	3.7	4.0	3.7	3.5	3.7	4.0	4.3	4.5	4.4
Metal Goods	10.1	10.0	9.9	9.8	9.6	9.5	9.5	9.5	9.5	9.6	9.6	9.6	9.6	9.7	9.7
Plant	3.3	3.3	3.2	3.1	3.1	3.2	3.2	3.2	3.3	3.4	3.5	3.5	3.5	3.5	3.5
Mech. Engineering	7.0	7.0	7.0	6.9	6.9	6.9	6.9	6.9	6.9	6.9	7.2	7.3	7.4	7.5	7.7
Elec. Engineering	11.0	10.8	10.5	10.3	10.1	9.9	9.7	9.7	9.7	9.7	9.7	9.6	9.6	9.7	9.8

Table A2.1: Total Capital Investment

Table A2.1C: Total Capital 1977-1990

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Investment (£M)														
Real Estate	7647	8182	9637	11802	12471	13386	13306	14646	15218	16514	19879	23968	31617	34807
Dwellings	5699	6325	7649	8674	8138	8920	10447	11718	11854	13622	15274	18857	20076	18449
Road Vehicles	2321	3112	3890	3383	3124	3842	3829	4419	5094	5448	6810	7729	8716	8663
Railway	79	98	126	163	136	123	101	75	106	95	126	203	200	383
Ships	528	533	308	355	221	326	284	502	332	168	236	109	100	189
Aircraft	212	261	359	665	365	-6	316	668	907	511	633	834	800	1119
Metal Goods	3019	3500	4069	4340	4273	4378	4549	4694	5676	5890	6340	7218	8498	8884
Plant	1395	1693	1958	2029	1934	2142	2292	2377	3193	3345	3642	4359	4926	5034
Mech. Engineering	2646	3189	3827	4222	3958	4219	4553	5385	5774	5717	6389	7321	8393	8647
Elec. Engineering	2647	3064	3686	4367	4902	5620	6541	7810	9227	9738	10703	12488	14385	15017
Total	26193	29957	35508	40000	39522	42950	46218	52294	57381	61048	70031	83086	97712	101192
Capital Stock (£M)														
Real Estate	160032	186142	223207	294099	330616	328738	332090	342122	362745	387482	412918	457885	540563	599976
Dwellings	143171	162391	195522	245628	283751	298408	318361	356705	390065	421368	463094	523387	598336	648482
Road Vehicles	9463	11973	14606	17143	17851	19470	19659	21135	23399	25709	29215	32472	36688	40083
Railway	585	644	733	847	947	963	991	951	961	955	1002	1089	1189	1428
Ships	6318	6778	7073	7350	7673	7529	7655	7665	7629	7392	7420	7055	6882	6597
Aircraft	1142	1327	1610	2169	2442	2159	2312	2711	3345	3502	3848	4236	4646	5204
Metal Goods	36063	41274	47105	53971	59851	65179	69454	72838	78153	81482	85680	89583	95765	104133
Plant	6085	7060	8157	9267	9970	10671	11241	11664	12967	13907	15045	16538	18493	20523
Mech. Engineering	25239	28792	32900	37791	41645	45189	48132	51117	55031	57265	60387	63538	68334	74467
Elec. Engineering	32653	37267	42544	49193	55560	62062	68343	74863	83719	90714	99032	107688	119289	133663
Total	420750	483649	573457	717458	810306	840367	878237	941771	1018015	1089775	1177641	1303471	1490184	1634557

Table A2.1: Total Capital Investment

Table A2.1C: Total Capital 1977-1990 (Cont)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Capital Growth (%)														
Real Estate	2.9%	2.5%	2.4%	2.1%	1.8%	2.2%	2.1%	2.4%	2.3%	2.4%	3.0%	3.4%	4.1%	4.0%
Dwellings	3.1%	3.0%	3.0%	2.6%	1.9%	2.1%	2.4%	2.4%	2.1%	2.3%	2.4%	2.7%	0.8%	1.6%
Road Vehicles	6.0%	8.1%	9.0%	-0.3%	-3.0%	-0.3%	-0.6%	1.1%	2.3%	1.5%	4.3%	5.0%	-0.4%	2.4%
Railway	-1.7%	0.3%	2.6%	5.2%	-0.8%	-2.6%	-5.4%	-7.7%	-4.5%	-5.6%	-2.8%	4.5%	-3.8%	12.6%
Ships	-1.8%	-2.3%	-5.9%	-5.4%	-7.3%	-5.9%	-6.5%	-3.7%	-5.9%	-7.9%	-7.0%	-8.6%	-14.0%	-10.1%
Aircraft	4.4%	5.8%	9.4%	22.6%	-0.1%	-15.2%	-1.5%	12.8%	16.6%	-0.5%	1.7%	5.8%	-3.3%	5.0%
Metal Goods	3.7%	3.8%	4.0%	3.3%	2.3%	1.8%	1.7%	1.5%	2.4%	2.4%	2.6%	3.3%	-5.7%	1.9%
Plant	3.8%	5.2%	5.3%	2.4%	-0.7%	0.1%	0.5%	0.5%	6.1%	5.3%	5.5%	8.6%	-1.4%	4.0%
Mech. Engineering	2.8%	3.5%	4.1%	3.6%	1.7%	1.5%	1.6%	2.8%	2.8%	2.2%	2.9%	4.0%	-5.2%	2.1%
Elec. Engineering	3.4%	3.5%	4.0%	4.3%	4.2%	4.5%	5.1%	6.1%	6.8%	6.4%	6.5%	7.5%	-2.3%	5.0%
Average Age (Years)														
Real Estate	17.5	17.6	17.8	18.1	18.4	18.6	18.8	18.9	19.1	19.3	19.3	19.2	19.0	18.9
Dwellings	23.2	23.3	23.3	23.5	23.8	24.0	24.2	24.4	24.6	24.8	24.9	25.0	25.1	25.4
Road Vehicles	3.3	3.2	3.1	3.3	3.5	3.6	3.7	3.7	3.7	3.7	3.6	3.5	3.4	3.5
Railway	7.8	7.4	7.0	6.4	6.4	6.4	6.7	7.1	7.2	7.4	7.3	6.8	6.5	5.5
Ships	6.8	7.2	7.8	8.4	9.1	9.7	10.3	10.5	11.0	11.8	12.4	13.1	13.9	14.5
Aircraft	4.4	4.3	4.1	3.6	3.9	4.9	5.1	4.6	4.1	4.3	4.5	4.4	4.5	4.3
Metal Goods	9.8	9.9	10.0	10.1	10.3	10.5	10.8	11.0	11.2	11.3	11.4	11.4	11.3	11.2
Plant	3.4	3.4	3.3	3.4	3.5	3.6	3.7	3.7	3.6	3.5	3.4	3.2	3.1	3.1
Mech. Engineering	7.8	7.8	7.8	7.8	7.9	8.1	8.3	8.3	8.3	8.4	8.4	8.3	8.2	8.1
Elec. Engineering	9.9	10.0	10.1	10.1	10.1	10.1	10.0	9.9	9.7	9.5	9.4	9.2	9.0	8.8

Table A2.1: Total Capital Investment

Table A2.2.5A: Investment for Distribution, Transport and Communication 1948-61
Table A2.2.5B: Investment for Distribution, Transport and Communication 1962-76
Table A2.2.5C: Investment for Distribution, Transport and Communication 1977-90

Table A2.2.6A: Investment for Services 1948-61
Table A2.2.6A: Investment for Services 1962-76
Table A2.2.6A: Investment for Services 1977-90

Notes:

The capital vector for each of the six industrial groups was then calculated using an *'industry-by-industry'* disaggregation of the capital vector as given in Table A2.4.1 below. The price deflators are taken by asset type rather than by industrial group, and are given in Table A2.5. The breakdown for the Plant and Machinery investment total are given in Table A2.6: below. This may not be totally consistent with the overall figures due to rounding errors.

A2.3: Other investment

Tables:

Table A2.3.1: Investment in transfer costs of real estate 1948-90
Table A2.3.2: Investment in working capital 1948-90

Notes:

The Transfer cost of existing land and buildings are included in the overall capital matrix in the 'real estate' column. It is calculated as per the industry figures. It is disaggregated by industries in proportion to the total holdings of real estate by each industrial group.

The total for working capital is given in Table A2.3.2. This is taken directly from the figures included in the *Blue Book*. The only problem concerns the distribution of the residual total included in 'other industries'. From 1982 onwards the figure is small (around 3.5% of total) and is allocated to transportation. Prior to 1982, construction is not separately identified and the 'residual' total increases correspondingly to around 10%. Equally, prior to 1960, wholesale distribution is also included in the residue. This pushes the unallocated portion up to *circa* 25%. The residue is distributed between the construction and the distribution and transportation industries so as to stabilize the proportions held by each industry as far as is possible.

Table A2.2.1A: Agriculture, Forestry, and Fishing 1947-1961

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Investment (£M)															
Real Estate	-	22	25	23	23	22	24	25	28	30	28	32	41	45	56
Road Road Vehicles	-	22	21	20	17	25	21	20	22	22	24	26	28	32	32
Metal Goods	-	4	4	4	5	4	4	5	5	4	5	7	7	7	7
Plant	-	42	42	43	47	43	42	48	52	43	54	66	71	67	69
Mech. Engineering	-	2	2	2	2	2	2	2	2	2	2	3	3	3	3
Elec. Engineering	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total	-	93	94	93	94	97	94	100	110	102	114	134	151	154	168
Capital Stock (£M)															
Real Estate	469	491	506	519	593	660	675	686	747	788	832	872	881	909	958
Road Vehicles	85	88	92	107	106	120	112	108	107	115	119	123	124	128	136
Metal Goods	94	95	96	98	105	115	117	116	121	126	130	133	134	135	140
Plant	189	189	196	204	222	240	241	241	254	258	268	286	301	310	325
Mech. Engineering	34	33	33	33	35	38	38	37	38	39	39	40	40	40	41
Elec. Engineering	9	10	10	10	11	12	12	12	13	13	14	14	14	14	15
Total	880	905	933	971	1073	1184	1195	1200	1280	1340	1402	1468	1494	1537	1615
Capital Growth (%)															
Real Estate	-	4.3%	3.1%	2.5%	2.0%	1.4%	1.6%	1.7%	1.8%	1.9%	1.4%	1.7%	2.8%	3.1%	4.1%
Road Road Vehicles	-	2.3%	3.8%	-1.6%	-4.8%	1.1%	-1.5%	-1.8%	0.6%	-1.1%	0.1%	1.5%	3.4%	6.7%	4.6%
Metal Goods	-	1.0%	-0.7%	-0.6%	-0.6%	-1.3%	-1.4%	-1.0%	-0.7%	-1.6%	-0.9%	-0.1%	0.3%	-0.1%	-0.1%
Plant	-	-0.4%	1.6%	1.5%	1.3%	-2.4%	-2.9%	-0.3%	0.5%	-3.9%	0.0%	3.9%	4.7%	1.9%	1.6%
Mech. Engineering	-	-1.2%	-2.6%	-2.3%	-2.2%	-3.0%	-3.1%	-2.4%	-2.0%	-3.2%	-2.1%	-0.8%	-0.2%	-0.7%	-0.6%
Elec. Engineering	-	1.8%	0.2%	0.0%	-0.2%	-0.8%	-0.9%	-0.6%	-0.4%	-1.2%	-0.6%	0.3%	0.6%	0.2%	0.2%
Average Age (Years)															
Real Estate	15.5	15.5	15.7	15.9	16.3	16.7	17.1	17.4	17.7	18.0	18.4	18.7	18.7	18.8	18.6
Road Vehicles	3.6	3.6	3.5	3.7	3.9	3.9	4.0	4.1	4.0	4.1	4.0	4.0	3.9	3.6	3.5
Metal Goods	16.0	16.0	16.2	16.5	16.7	17.0	17.4	17.6	17.8	18.2	18.4	18.4	18.4	18.5	18.5
Plant	4.1	4.1	4.0	3.9	3.9	4.0	4.1	4.1	4.1	4.2	4.2	4.0	3.8	3.8	3.8
Mech. Engineering	13.6	13.6	13.7	13.9	14.0	14.2	14.5	14.6	14.6	14.9	14.9	14.7	14.5	14.4	14.2
Elec. Engineering	14.0	14.0	14.2	14.5	14.7	15.1	15.4	15.7	15.9	16.3	16.5	16.6	16.6	16.7	16.8

Table A2.2.1: Capital Invested for Agriculture, Forestry, and Fishing

Table A2.2.1B: Agriculture, Forestry, and Fishing 1962-1976															
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Investment (£M)															
Real Estate	61	66	67	70	68	78	95	102	119	137	163	220	262	248	234
Road Road Vehicles	28	24	24	27	25	26	29	28	26	48	56	64	65	83	79
Metal Goods	6	8	9	9	9	9	10	10	12	13	18	25	25	30	44
Plant	64	75	86	86	87	90	104	95	108	111	144	196	186	222	317
Mech. Engineering	3	3	4	4	4	4	5	4	3	3	3	2	1	1	1
Elec. Engineering	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
Total	163	177	190	196	194	208	244	240	269	313	385	509	541	586	677
Capital Stock (£M)															
Real Estate	1039	1124	1202	1282	1375	1421	1556	1686	1888	2167	2556	3263	4467	5628	6295
Road Road Vehicles	138	129	128	132	131	133	139	144	148	179	207	244	294	401	461
Metal Goods	143	145	149	156	163	164	172	180	197	218	238	268	313	396	494
Plant	331	343	367	391	413	421	452	472	517	564	624	733	850	1058	1330
Mech. Engineering	42	42	44	46	48	48	50	52	55	58	59	61	65	74	83
Elec. Engineering	15	15	16	17	17	18	18	19	21	23	25	27	31	39	46
Total	1708	1799	1905	2024	2147	2205	2386	2553	2827	3210	3708	4596	6019	7595	8709
Capital Growth (%)															
Real Estate	4.1%	4.1%	3.8%	3.7%	3.1%	3.7%	4.4%	4.3%	4.6%	4.6%	4.7%	5.1%	4.1%	2.5%	1.8%
Road Vehicles	0.4%	-1.8%	-1.5%	0.6%	-1.1%	-0.5%	1.2%	-0.8%	-3.0%	9.2%	9.7%	8.5%	2.7%	0.9%	-3.5%
Metal Goods	-0.5%	0.2%	0.8%	0.5%	0.4%	0.5%	1.1%	0.6%	1.1%	1.0%	2.6%	4.7%	3.2%	2.8%	4.3%
Plant	-0.8%	2.5%	4.4%	2.4%	1.5%	1.7%	3.9%	0.2%	1.0%	-0.4%	4.1%	9.1%	2.5%	1.2%	5.0%
Mech. Engineering	-1.3%	-0.1%	0.8%	0.4%	0.2%	0.4%	1.3%	-1.1%	-2.0%	-3.4%	-3.8%	-4.4%	-6.6%	-6.7%	-6.5%
Elec. Engineering	-0.3%	0.5%	1.1%	0.8%	0.6%	0.7%	1.3%	0.4%	0.6%	0.1%	1.2%	2.6%	1.1%	0.0%	-0.1%
Average Age (Years)															
Real Estate	18.5	18.3	18.2	18.2	18.2	18.2	18.0	17.9	17.7	17.5	17.3	17.1	17.0	17.2	17.5
Road Vehicles	3.6	3.8	3.9	3.9	3.9	4.0	3.9	4.0	4.1	3.7	3.5	3.3	3.3	3.4	3.7
Metal Goods	18.6	18.6	18.5	18.4	18.4	18.3	18.1	18.1	17.9	17.8	17.4	16.7	16.3	16.0	15.5
Plant	3.8	3.8	3.7	3.6	3.7	3.7	3.6	3.7	3.7	3.8	3.7	3.4	3.5	3.5	3.4
Mech. Engineering	14.2	14.0	13.7	13.5	13.3	13.1	12.8	12.8	13.0	13.3	13.7	14.1	14.9	15.7	16.4
Elec. Engineering	16.9	17.0	16.9	16.9	16.9	16.8	16.7	16.8	16.8	16.9	16.8	16.5	16.4	16.5	16.7

Table A2.2.1: Capital Invested for Agriculture, Forestry, and Fishing

Table A2.2.1C: Agriculture, Forestry, and Fishing 1977-1990														
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Investment (£M)														
Real Estate	253	337	401	562	518	619	653	716	554	467	535	521	555	603
Road Road Vehicles	106	126	109	94	110	121	133	136	81	142	142	147	175	169
Metal Goods	53	62	58	59	58	82	98	97	49	53	53	68	68	63
Plant	371	425	389	368	336	442	492	453	483	519	520	665	669	622
Mech. Engineering	1	1	1	6	10	20	30	35	7	7	7	9	9	9
Elec. Engineering	2	2	1	5	8	15	23	27	7	8	8	10	10	9
Total	786	953	959	1093	1040	1299	1429	1464	1181	1196	1265	1420	1486	1475
Capital Stock (£M)														
Real Estate	6866	7972	9547	12637	14188	14152	14377	14893	15682	16505	17276	18676	21313	22887
Road Road Vehicles	555	646	687	741	747	775	763	785	761	801	840	858	914	952
Metal Goods	591	680	767	866	950	1047	1140	1215	1258	1270	1290	1308	1342	1398
Plant	1591	1829	1995	2138	2191	2316	2435	2465	2548	2595	2648	2808	2972	3111
Mech. Engineering	89	91	93	101	111	129	154	182	182	178	175	172	172	174
Elec. Engineering	52	57	60	68	78	94	117	141	148	151	154	158	164	172
Total	9744	11275	13150	16552	18264	18513	18985	19681	20579	21498	22383	23980	26878	28694
Capital Growth (%)														
Real Estate	1.7%	2.3%	2.3%	2.6%	1.7%	2.5%	2.7%	2.9%	1.6%	0.9%	1.1%	0.8%	0.6%	0.7%
Road Vehicles	-1.1%	-0.6%	-4.9%	-8.4%	-6.2%	-5.2%	-3.1%	-3.2%	-10.5%	-2.8%	-3.7%	-3.5%	-1.1%	-2.7%
Metal Goods	4.3%	4.4%	2.7%	1.9%	1.1%	3.0%	3.9%	3.2%	-1.1%	-0.9%	-0.9%	0.2%	0.1%	-0.5%
Plant	4.3%	4.2%	-0.6%	-3.4%	-5.5%	-1.1%	0.3%	-2.0%	-1.3%	0.0%	-0.4%	4.8%	3.2%	0.0%
Mech. Engineering	-6.6%	-6.7%	-7.0%	-2.3%	1.2%	8.8%	14.3%	14.2%	-4.5%	-4.1%	-4.0%	-2.8%	-2.7%	-3.2%
Elec. Engineering	-1.0%	-2.0%	-3.4%	2.0%	5.6%	13.4%	18.2%	17.3%	-0.2%	0.1%	0.0%	1.3%	1.1%	0.3%
Average Age (Years)														
Real Estate	17.9	18.1	18.3	18.4	18.7	18.8	18.9	19.0	19.3	19.7	20.1	20.5	20.9	21.3
Road Vehicles	3.8	3.9	4.1	4.4	4.6	4.8	4.8	4.8	5.1	5.1	5.0	5.0	4.8	4.8
Metal Goods	15.0	14.6	14.4	14.4	14.4	14.2	13.9	13.7	14.2	14.5	14.9	15.1	15.2	15.5
Plant	3.4	3.4	3.5	3.7	4.0	4.1	4.0	4.1	4.1	4.1	4.1	3.9	3.8	3.8
Mech. Engineering	17.2	17.9	18.7	18.6	17.8	15.9	13.6	11.8	12.3	12.7	13.2	13.4	13.6	13.9
Elec. Engineering	17.0	17.4	18.1	17.8	16.9	15.0	12.9	11.2	11.6	12.0	12.4	12.5	12.7	13.0

Table A2.2.1: Capital Invested for Agriculture, Forestry, and Fishing

Table A2.2.2A: Energy and Water Supply 1947-1961

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Investment (£M)															
Real Estate		49	66	69	77	88	103	121	127	141	151	163	166	154	161
Road Road Vehicles		3	5	4	4	3	3	5	5	4	5	4	5	5	5
Metal Goods		41	48	56	61	71	80	93	109	105	110	119	136	130	141
Plant		9	10	12	13	15	17	20	23	22	24	25	29	28	30
Mech. Engineering		12	14	17	18	21	24	28	33	32	33	36	41	39	42
Elec. Engineering		47	55	64	70	81	92	106	124	120	127	136	156	149	162
Total		160	199	221	244	279	320	373	421	424	450	483	534	505	541
Capital Stock (£M)															
Real Estate	798	847	897	947	1119	1290	1376	1468	1666	1832	2019	2203	2287	2398	2539
Road Vehicles	14	14	16	19	20	21	19	20	21	22	23	23	23	23	23
Metal Goods	364	392	427	472	544	642	712	771	877	987	1082	1174	1259	1337	1453
Plant	34	35	39	44	51	60	67	74	85	95	102	109	117	122	131
Mech. Engineering	165	166	171	178	195	219	233	243	267	291	311	330	346	360	385
Elec. Engineering	388	421	463	515	597	708	788	857	979	1105	1214	1321	1419	1509	1642
Total	1763	1875	2013	2176	2526	2942	3195	3433	3894	4332	4752	5161	5452	5750	6174
Capital Growth (%)															
Real Estate	-	5.8%	5.8%	5.7%	5.2%	5.2%	5.9%	6.8%	6.1%	6.2%	5.9%	5.8%	5.7%	4.7%	4.6%
Road Vehicles	-	-1.0%	16.2%	1.0%	-0.1%	-6.6%	-4.9%	7.0%	5.5%	-2.1%	2.0%	-3.0%	2.5%	2.7%	1.7%
Metal Goods	-	7.4%	7.0%	7.7%	7.0%	6.7%	7.1%	8.0%	8.4%	6.3%	5.8%	5.7%	6.5%	5.2%	5.2%
Plant	-	1.9%	8.7%	9.7%	7.7%	6.8%	7.6%	9.6%	10.1%	4.9%	4.2%	4.3%	6.6%	3.6%	3.9%
Mech. Engineering	-	0.5%	0.5%	1.6%	1.6%	1.9%	2.7%	4.0%	4.8%	3.2%	3.0%	3.2%	4.4%	3.2%	3.4%
Elec. Engineering	-	8.2%	7.9%	8.4%	7.7%	7.3%	7.6%	8.5%	8.8%	6.6%	6.1%	5.9%	6.8%	5.4%	5.4%
Average Age (Years)															
Real Estate	12.6	12.6	12.6	12.6	12.7	12.8	12.7	12.6	12.6	12.5	12.5	12.5	12.5	12.7	12.8
Road Vehicles	4.2	4.2	3.6	3.6	3.7	4.0	4.2	3.9	3.7	3.9	3.8	4.0	3.9	3.8	3.8
Metal Goods	7.7	7.7	7.7	7.7	7.7	7.7	7.8	7.7	7.6	7.7	7.8	7.9	8.0	8.1	8.2
Plant	3.7	3.7	3.4	3.2	3.1	3.1	3.0	3.0	2.9	3.0	3.0	3.1	3.1	3.1	3.2
Mech. Engineering	10.9	10.9	10.9	10.7	10.6	10.5	10.3	10.0	9.7	9.5	9.4	9.3	9.0	9.0	8.9
Elec. Engineering	7.2	7.2	7.2	7.2	7.2	7.3	7.3	7.3	7.2	7.3	7.5	7.6	7.7	7.8	7.9

Table A2.2.2: Capital Investment for Energy and Water Supply

Table A2.2.2B: Energy and Water Supply 1962-1976															
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Investment (£M)															
Real Estate	183	187	235	258	301	359	337	326	342	355	369	442	882	1663	1976
Road Road Vehicles	4	5	2	5	7	7	8	8	10	12	12	12	16	44	31
Metal Goods	157	199	227	243	290	302	244	213	218	229	280	276	386	567	842
Plant	34	43	49	52	62	65	52	44	44	45	53	51	70	117	195
Mech. Engineering	47	60	68	73	87	91	73	61	60	60	70	66	89	146	239
Elec. Engineering	180	228	260	279	333	346	280	227	215	210	238	218	282	393	552
Total	604	722	841	911	1081	1170	995	880	889	910	1022	1066	1724	2930	3834
Capital Stock (£M)															
Real Estate	2777	3014	3277	3564	3934	4200	4655	5065	5658	6438	7478	9345	12925	17232	20532
Road Road Vehicles	23	22	20	21	24	27	30	33	38	46	51	56	69	118	144
Metal Goods	1575	1712	1890	2114	2378	2569	2764	2949	3256	3616	3930	4298	5002	6410	8134
Plant	142	157	177	200	228	248	257	259	268	280	291	302	343	454	630
Mech. Engineering	411	442	484	537	601	646	687	720	778	843	894	953	1080	1367	1744
Elec. Engineering	1783	1941	2146	2403	2706	2927	3150	3345	3661	4018	4294	4613	5236	6510	7957
Total	6710	7289	7994	8839	9872	10617	11544	12371	13660	15241	16939	19567	24655	32092	39140
Capital Growth (%)															
Real Estate	4.9%	4.5%	5.6%	5.6%	6.1%	7.2%	5.6%	4.7%	4.3%	3.7%	3.1%	2.9%	5.2%	8.5%	8.4%
Road Vehicles	-3.1%	2.9%	-11.2%	4.3%	12.5%	8.3%	9.0%	5.3%	8.4%	8.4%	4.9%	1.9%	4.3%	27.5%	2.0%
Metal Goods	5.5%	7.5%	8.0%	7.4%	8.2%	7.7%	4.2%	2.4%	1.8%	1.4%	2.3%	1.5%	2.9%	4.2%	6.0%
Plant	4.9%	9.8%	10.3%	8.3%	9.9%	8.2%	0.4%	-3.5%	-4.3%	-4.8%	-2.1%	-3.7%	0.4%	7.7%	15.8%
Mech. Engineering	3.9%	6.4%	7.1%	6.5%	7.6%	7.1%	3.0%	0.5%	-0.4%	-1.0%	-0.2%	-1.1%	0.2%	3.0%	6.6%
Elec. Engineering	5.6%	7.7%	8.1%	7.5%	8.3%	7.8%	4.3%	1.9%	0.9%	0.2%	0.6%	-0.3%	0.4%	1.1%	2.1%
Average Age (Years)															
Real Estate	12.9	13.0	13.0	13.0	12.9	12.7	12.7	12.9	13.0	13.2	13.5	13.9	13.8	13.4	13.0
Road Vehicles	3.9	3.8	4.4	4.1	3.6	3.4	3.2	3.2	3.1	3.0	3.1	3.2	3.2	2.7	2.9
Metal Goods	8.3	8.2	8.1	8.1	7.9	7.9	8.1	8.5	8.8	9.2	9.5	9.8	10.0	10.0	9.9
Plant	3.2	3.1	2.9	2.9	2.8	2.8	3.1	3.4	3.7	3.9	4.0	4.2	4.1	3.8	3.3
Mech. Engineering	8.7	8.4	8.1	7.8	7.6	7.4	7.5	7.7	8.1	8.4	8.7	9.0	9.2	9.1	8.7
Elec. Engineering	8.0	8.0	7.9	7.9	7.8	7.7	7.9	8.3	8.8	9.3	9.7	10.2	10.6	10.9	11.1

Table A2.2.2: Capital Investment for Energy and Water Supply

Table A2.2.2C: Energy and Water Supply 1977-1990														
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Investment (£M)														
Real Estate	1971	2039	2081	2729	3237	3321	3206	3316	3159	3038	2909	3162	3628	3798
Road Road Vehicles	21	40	57	113	9	45	127	82	89	121	131	131	138	222
Metal Goods	873	997	1114	1276	1472	1508	1592	1430	1444	1483	1308	1389	1700	1917
Plant	224	282	344	380	422	415	419	360	464	477	420	446	546	616
Mech. Engineering	271	337	407	419	426	377	334	241	190	196	172	183	224	253
Elec. Engineering	538	576	599	783	1018	1163	1358	1341	1447	1487	1311	1393	1704	1922
Total	3899	4270	4602	5700	6584	6829	7037	6770	6793	6802	6252	6704	7940	8727
Capital Stock (£M)														
Real Estate	23540	28216	34455	46305	53328	54187	55752	58293	62373	66825	70693	77450	89714	97596
Road Road Vehicles	161	191	228	327	290	299	370	397	433	496	563	608	662	789
Metal Goods	9735	11194	12786	14748	16660	18432	19946	21000	22340	23091	23792	24261	25333	27113
Plant	802	989	1212	1456	1684	1856	1976	1992	2133	2214	2236	2256	2397	2624
Mech. Engineering	2111	2478	2910	3388	3805	4121	4308	4334	4367	4286	4214	4106	4098	4199
Elec. Engineering	9208	10220	11255	12642	14036	15421	16715	17740	19100	19961	20748	21338	22490	24290
Total	45556	53288	62846	78866	89803	94315	99067	103757	110746	116874	122246	130018	144694	156612
Capital Growth (%)														
Real Estate	7.0%	5.6%	4.3%	4.1%	4.3%	4.4%	4.0%	3.9%	3.2%	2.7%	2.2%	2.2%	2.1%	2.0%
Road Vehicles	-8.0%	1.2%	6.7%	22.2%	-17.4%	-5.8%	21.8%	0.8%	0.7%	5.8%	4.3%	2.0%	1.1%	11.3%
Metal Goods	4.4%	4.3%	4.1%	4.0%	4.2%	3.5%	3.2%	1.9%	1.6%	1.5%	0.5%	0.8%	1.8%	2.2%
Plant	11.0%	11.9%	11.7%	8.3%	6.7%	3.0%	1.6%	-2.4%	2.2%	1.9%	-1.5%	-0.3%	3.6%	4.5%
Mech. Engineering	5.5%	6.5%	7.0%	5.0%	3.6%	1.3%	-0.3%	-2.6%	-3.8%	-3.6%	-4.1%	-3.7%	-2.7%	-2.1%
Elec. Engineering	0.9%	0.7%	0.3%	1.3%	2.4%	2.7%	3.4%	2.8%	2.8%	2.6%	1.4%	1.6%	2.8%	3.2%
Average Age (Years)														
Real Estate	12.9	12.8	13.0	13.2	13.3	13.4	13.6	13.8	14.0	14.4	14.7	15.1	15.4	15.8
Road Vehicles	3.4	3.4	3.3	2.8	3.7	4.0	3.3	3.4	3.5	3.4	3.4	3.4	3.5	3.2
Metal Goods	9.9	9.9	10.0	10.0	10.0	10.1	10.2	10.5	10.7	11.0	11.3	11.6	11.8	11.9
Plant	3.1	2.9	2.8	2.8	2.9	3.0	3.2	3.4	3.4	3.5	3.6	3.7	3.6	3.6
Mech. Engineering	8.5	8.2	7.9	7.8	7.8	8.0	8.3	8.8	9.4	9.9	10.4	10.9	11.3	11.5
Elec. Engineering	11.4	11.7	12.0	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.4	12.5	12.5	12.4

Table A2.2.2: Capital Investment for Energy and Water Supply

Table A2.2.3A: Manufacturing 1947-1961															
	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Investment (£M)															
Real Estate		85	95	110	115	131	130	143	191	254	268	247	222	264	311
Road Road Vehicles		26	28	31	33	35	33	35	42	45	40	52	59	75	73
Metal Goods		71	83	99	121	126	126	135	149	181	208	203	194	227	280
Plant		26	31	36	45	46	47	50	55	67	77	75	72	84	103
Mech. Engineering		104	121	145	177	185	185	197	218	265	305	298	285	333	411
Elec. Engineering		16	19	23	28	29	29	31	35	42	49	47	45	53	65
Total		328	377	444	519	553	551	591	689	854	947	922	877	1035	1243
Capital Stock (£M)															
Real Estate	2393	2470	2518	2576	2948	3300	3385	3458	3815	4127	4476	4769	4813	4987	5257
Road Vehicles	70	78	91	117	131	152	148	151	162	185	193	209	222	247	274
Metal Goods	664	710	770	850	991	1167	1273	1347	1491	1681	1863	2021	2127	2265	2502
Plant	52	64	82	104	134	165	183	197	220	253	286	310	321	343	387
Mech. Engineering	802	847	916	1010	1178	1383	1502	1583	1745	1965	2179	2357	2467	2623	2903
Elec. Engineering	159	169	183	202	235	276	301	318	351	396	438	475	499	531	587
Total	4140	4339	4561	4860	5617	6443	6793	7054	7784	8607	9436	10142	10449	10996	11909
Capital Growth (%)															
Real Estate	-	2.9%	1.8%	2.4%	2.0%	2.1%	1.9%	2.2%	3.2%	4.4%	4.2%	3.4%	2.7%	3.5%	4.2%
Road Road Vehicles	-	11.4%	15.7%	8.7%	7.0%	4.0%	2.9%	4.0%	8.0%	5.7%	0.9%	6.5%	9.0%	14.9%	9.1%
Metal Goods	-	6.6%	6.4%	7.5%	8.2%	6.5%	5.5%	5.5%	5.5%	6.5%	7.0%	5.6%	4.6%	5.6%	7.0%
Plant	-	21.7%	27.0%	23.0%	19.8%	11.3%	7.3%	7.0%	6.6%	8.6%	9.3%	5.4%	2.9%	5.8%	9.1%
Mech. Engineering	-	5.4%	6.1%	7.4%	8.3%	6.2%	5.0%	5.1%	5.1%	6.4%	7.0%	5.3%	4.0%	5.4%	7.2%
Elec. Engineering	-	6.3%	6.2%	7.2%	8.0%	6.3%	5.3%	5.4%	5.4%	6.3%	6.8%	5.5%	4.5%	5.5%	6.9%
Average Age (Years)															
Real Estate	20.0	20.0	20.2	20.3	20.4	20.6	20.8	20.9	20.8	20.4	20.1	20.0	20.1	20.0	19.7
Road Vehicles	2.5	2.5	2.5	2.5	2.6	2.8	3.0	3.0	3.0	3.0	3.2	3.1	3.0	2.8	2.8
Metal Goods	8.2	8.2	8.2	8.1	8.0	8.0	8.1	8.2	8.3	8.3	8.3	8.3	8.5	8.5	8.5
Plant	1.9	1.9	1.8	1.8	1.9	2.1	2.3	2.5	2.6	2.7	2.7	2.8	2.9	3.0	2.9
Mech. Engineering	6.9	6.9	6.8	6.7	6.6	6.5	6.6	6.7	6.7	6.7	6.6	6.6	6.8	6.8	6.7
Elec. Engineering	8.4	8.4	8.4	8.3	8.2	8.2	8.3	8.4	8.5	8.5	8.4	8.5	8.6	8.7	8.6

Table A2.2.3: Capital Investment for Manufacturing

Table A2.2.3B: Manufacturing 1962-1976															
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Investment (£M)															
Real Estate	286	236	275	315	310	270	303	366	391	383	353	439	591	617	545
Road Road Vehicles	58	67	81	88	84	87	97	109	115	127	151	175	214	209	290
Metal Goods	273	249	286	333	366	367	389	450	521	533	462	545	699	799	914
Plant	101	92	105	123	135	135	143	168	197	205	180	216	280	320	366
Mech. Engineering	400	366	419	488	537	539	570	668	783	813	713	853	1108	1289	1502
Elec. Engineering	64	58	67	78	85	86	91	105	123	126	110	131	169	224	293
Total	1182	1068	1232	1425	1518	1484	1592	1867	2130	2187	1969	2358	3062	3458	3910
Capital Stock (£M)															
Real Estate	5656	5993	6325	6695	7135	7237	7744	8249	9049	10112	11518	14152	18829	23297	25632
Road Road Vehicles	279	280	306	339	356	378	409	453	498	569	629	721	892	1173	1409
Metal Goods	2716	2859	3062	3364	3689	3884	4198	4605	5265	6009	6528	7226	8460	10682	13064
Plant	418	430	457	504	554	580	623	687	793	900	945	1030	1212	1512	1815
Mech. Engineering	3144	3291	3514	3857	4226	4441	4787	5257	6028	6884	7444	8230	9668	12227	14971
Elec. Engineering	636	669	717	787	863	908	981	1077	1232	1408	1531	1698	1992	2551	3194
Total	12849	13523	14382	15545	16823	17428	18741	20327	22865	25881	28596	33056	41054	51442	60085
Capital Growth (%)															
Real Estate	3.2%	2.0%	2.5%	2.8%	2.5%	1.8%	2.0%	2.5%	2.4%	1.9%	1.1%	1.1%	1.2%	0.7%	0.1%
Road Vehicles	1.0%	5.2%	8.7%	8.1%	4.7%	3.9%	4.9%	5.4%	4.0%	3.0%	5.3%	5.6%	5.2%	-2.7%	0.7%
Metal Goods	5.6%	4.1%	4.8%	5.4%	5.5%	4.9%	4.7%	5.3%	5.4%	4.2%	2.2%	2.7%	3.6%	2.7%	2.1%
Plant	5.3%	1.7%	3.9%	5.8%	5.8%	4.3%	3.9%	5.9%	6.5%	3.6%	-1.2%	1.2%	4.1%	1.5%	0.2%
Mech. Engineering	5.4%	3.5%	4.4%	5.3%	5.4%	4.7%	4.4%	5.4%	5.7%	4.3%	1.7%	2.6%	3.9%	2.8%	2.3%
Elec. Engineering	5.6%	4.0%	4.7%	5.4%	5.4%	4.9%	4.7%	5.3%	5.5%	4.4%	2.4%	2.9%	3.8%	4.1%	4.6%
Average Age (Years)															
Real Estate	19.7	19.9	20.0	20.0	20.1	20.3	20.4	20.5	20.6	20.7	21.1	21.4	21.7	22.1	22.6
Road Vehicles	3.0	3.1	3.0	2.9	3.0	3.1	3.1	3.1	3.2	3.2	3.2	3.2	3.2	3.4	3.5
Metal Goods	8.5	8.7	8.8	8.8	8.8	8.9	9.0	9.0	9.0	9.1	9.4	9.6	9.8	9.9	10.2
Plant	3.0	3.1	3.2	3.2	3.1	3.2	3.2	3.2	3.1	3.2	3.4	3.5	3.4	3.5	3.6
Mech. Engineering	6.7	6.8	6.9	6.9	6.9	6.9	7.0	7.0	6.9	7.0	7.2	7.4	7.4	7.5	7.7
Elec. Engineering	8.6	8.8	8.9	8.9	8.9	9.0	9.1	9.1	9.1	9.2	9.4	9.6	9.7	9.8	9.8

Table A2.2.3: Capital Investment for Manufacturing

Table A2.2.3C: Manufacturing 1977-1990	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Investment (£M)														
Real Estate	647	805	995	1052	858	752	624	930	1170	1133	1241	1528	1964	2233
Road Road Vehicles	419	471	541	582	481	572	607	684	719	711	768	755	926	877
Metal Goods	1066	1238	1386	1438	1150	1116	1093	1204	1578	1512	1688	1917	2180	2243
Plant	427	495	554	583	474	468	468	530	661	633	707	803	913	939
Mech. Engineering	1785	2113	2413	2785	2489	2715	3011	3792	4278	4100	4577	5197	5911	6082
Elec. Engineering	386	502	626	755	702	794	910	1181	1713	1642	1833	2081	2367	2435
Total	4730	5624	6515	7195	6154	6417	6714	8321	10118	9731	10814	12281	14260	14809
Capital Stock (£M)														
Real Estate	27573	31467	37099	47972	52752	51069	50147	50380	52346	54665	56690	61101	69879	75293
Road Road Vehicles	1791	2148	2463	2903	2975	3176	3189	3396	3660	3880	4150	4269	4604	4820
Metal Goods	15299	17263	19385	21863	23664	25155	26142	26853	28298	28883	29812	30575	31965	34036
Plant	2092	2340	2609	2898	2987	3023	3003	3011	3184	3226	3352	3516	3797	4120
Mech. Engineering	17581	19947	22555	25799	28218	30476	32401	34577	37597	39317	41652	43973	47394	51731
Elec. Engineering	3866	4552	5372	6415	7309	8219	9095	10104	11767	13023	14514	16033	17985	20324
Total	68202	77717	89484	107850	117904	121117	123977	128322	136852	142996	150170	159469	175624	190323
Capital Growth (%)														
Real Estate	0.4%	0.6%	0.7%	0.2%	-0.4%	-0.5%	-0.8%	-0.2%	0.2%	0.1%	0.2%	0.5%	0.8%	1.0%
Road Vehicles	4.4%	2.5%	2.5%	0.1%	-4.6%	-2.4%	-1.2%	0.2%	-0.4%	-2.1%	-1.8%	-2.8%	0.1%	-2.2%
Metal Goods	2.1%	2.3%	2.3%	1.7%	-0.1%	-0.6%	-0.9%	-0.5%	0.6%	0.2%	0.7%	1.4%	2.0%	1.7%
Plant	0.5%	1.5%	1.6%	0.1%	-4.9%	-5.3%	-5.2%	-2.9%	0.9%	-0.5%	1.4%	3.7%	5.3%	3.6%
Mech. Engineering	2.4%	2.9%	3.0%	3.1%	0.9%	1.0%	1.4%	3.3%	3.8%	2.7%	3.4%	4.3%	5.1%	4.3%
Elec. Engineering	5.5%	6.8%	7.5%	7.7%	5.1%	5.2%	5.6%	7.6%	11.2%	8.7%	8.7%	9.2%	9.4%	7.9%
Average Age (Years)														
Real Estate	23.0	23.4	23.8	24.2	24.8	25.4	26.1	26.6	27.0	27.4	27.8	28.1	28.3	28.4
Road Vehicles	3.5	3.5	3.5	3.6	3.9	4.0	4.0	4.0	4.0	4.1	4.2	4.3	4.2	4.3
Metal Goods	10.4	10.6	10.8	11.0	11.4	11.9	12.3	12.7	13.0	13.2	13.4	13.5	13.5	13.6
Plant	3.7	3.7	3.7	3.7	4.0	4.2	4.4	4.5	4.3	4.3	4.2	4.0	3.8	3.7
Mech. Engineering	7.8	7.9	7.9	8.0	8.2	8.3	8.5	8.4	8.4	8.4	8.4	8.3	8.1	8.0
Elec. Engineering	9.7	9.5	9.3	9.1	9.1	9.2	9.1	9.0	8.5	8.3	8.1	7.9	7.8	7.7

Table A2.2.3: Capital Investment for Manufacturing

Table A2.2.4A: Construction 1947-1961	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Investment (£M)															
Real Estate	-	3	3	4	5	5	6	8	9	11	10	8	8	9	10
Road Road Vehicles	-	8	11	9	13	14	13	13	17	18	17	21	22	28	34
Metal Goods	-	1	1	1	1	1	1	1	2	2	2	2	2	2	3
Plant	-	7	7	8	9	11	10	14	15	15	19	21	19	21	26
Mech. Engineering	-	3	3	3	4	5	4	6	7	7	8	9	8	9	11
Elec. Engineering	-	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Total	-	22	25	25	33	36	35	44	50	53	57	62	61	70	86
Capital Stock (£M)															
Real Estate	21	24	27	30	38	46	52	58	70	82	94	103	107	114	123
Road Vehicles	22	24	31	38	45	54	54	55	61	71	76	82	86	95	111
Metal Goods	4	5	5	6	7	8	9	10	12	13	15	17	18	19	22
Plant	21	23	25	28	34	41	44	49	56	63	71	79	83	87	99
Mech. Engineering	14	16	18	20	24	29	32	35	41	46	52	58	62	67	75
Elec. Engineering	2	3	3	4	4	5	6	7	8	9	10	11	12	13	14
Total	84	95	109	126	152	183	196	216	248	284	317	350	368	395	443
Capital Growth (%)															
Real Estate	-	13.7%	10.3%	12.9%	12.7%	9.9%	10.9%	13.5%	12.4%	13.1%	9.7%	6.3%	5.9%	6.4%	6.7%
Road Vehicles	-	11.3%	25.0%	4.8%	12.8%	8.0%	5.4%	4.5%	11.0%	7.3%	3.2%	7.4%	7.5%	13.5%	15.3%
Metal Goods	-	12.0%	8.9%	8.6%	9.5%	8.6%	6.4%	10.3%	8.8%	7.0%	8.5%	8.3%	6.5%	6.4%	8.2%
Plant	-	7.9%	9.6%	8.7%	10.6%	8.4%	3.8%	12.9%	9.0%	5.1%	8.8%	8.4%	4.4%	4.7%	9.1%
Mech. Engineering	-	14.1%	10.8%	10.1%	11.0%	9.6%	6.6%	11.6%	9.5%	7.1%	9.0%	8.7%	6.3%	6.2%	8.5%
Elec. Engineering	-	16.3%	12.1%	9.6%	10.5%	9.4%	7.1%	11.0%	9.3%	7.4%	8.9%	8.7%	6.8%	6.6%	8.4%
Average Age (Years)															
Real Estate	6.2	6.2	6.4	6.5	6.5	6.7	6.8	6.7	6.7	6.7	6.9	7.3	7.6	8.0	8.2
Road Vehicles	2.6	2.6	2.3	2.5	2.5	2.6	2.7	2.8	2.8	2.8	3.0	2.9	2.9	2.8	2.6
Metal Goods	5.6	5.6	5.8	5.9	6.0	6.1	6.4	6.3	6.4	6.6	6.6	6.7	6.9	7.0	7.0
Plant	2.9	2.9	2.8	2.8	2.8	2.8	2.9	2.8	2.8	2.9	2.8	2.8	2.9	3.0	2.9
Mech. Engineering	4.2	4.2	4.3	4.4	4.5	4.6	4.8	4.8	4.9	5.1	5.1	5.2	5.3	5.5	5.5
Elec. Engineering	4.5	4.5	4.6	4.9	5.1	5.3	5.5	5.6	5.7	6.0	6.1	6.2	6.4	6.6	6.6

Table A2.2.4: Capital Invested for Construction

Table A2.2.4B: Construction 1962-1976	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Investment (£M)															
Real Estate	9	11	14	20	21	19	23	18	16	12	11	34	34	60	44
Road Road Vehicles	28	34	40	38	39	41	46	52	48	48	58	87	102	111	116
Metal Goods	2	3	5	5	5	6	6	6	8	8	10	15	19	22	25
Plant	23	34	48	54	46	57	60	55	62	59	61	85	102	111	120
Mech. Engineering	10	15	21	23	20	25	26	23	25	23	23	31	35	41	47
Elec. Engineering	2	2	3	4	3	4	4	3	3	3	2	3	3	5	8
Total	74	99	130	144	133	151	165	158	162	153	165	254	295	349	360
Capital Stock (£M)															
Real Estate	135	148	164	185	210	224	253	276	305	340	387	494	671	868	979
Road Road Vehicles	118	124	140	152	161	173	189	210	226	248	267	319	402	545	636
Metal Goods	23	26	30	35	39	43	48	54	64	75	85	101	128	171	219
Plant	104	118	144	174	190	210	233	249	278	303	318	359	427	530	628
Mech. Engineering	81	90	105	124	138	152	171	187	211	236	253	282	329	413	502
Elec. Engineering	15	17	20	23	26	28	32	35	39	43	46	50	56	71	88
Total	476	523	602	693	764	830	925	1011	1124	1245	1356	1606	2013	2598	3053
Capital Growth (%)															
Real Estate	5.0%	5.9%	7.2%	9.9%	8.9%	7.1%	7.8%	4.8%	3.4%	1.6%	0.9%	5.2%	3.2%	5.3%	2.6%
Road Vehicles	5.0%	10.3%	12.1%	6.6%	5.5%	4.9%	5.8%	6.3%	1.5%	-0.8%	2.2%	10.0%	7.2%	0.5%	-2.2%
Metal Goods	5.5%	9.3%	13.0%	12.3%	7.6%	9.5%	8.6%	7.7%	8.7%	7.2%	7.2%	11.0%	11.6%	8.7%	7.0%
Plant	2.8%	12.1%	19.4%	15.8%	5.3%	9.8%	7.7%	2.8%	2.8%	-0.7%	-1.0%	4.8%	5.1%	1.1%	-1.1%
Mech. Engineering	5.0%	9.9%	14.4%	13.3%	7.3%	9.8%	8.5%	5.0%	4.3%	1.9%	1.2%	3.2%	3.1%	2.1%	1.6%
Elec. Engineering	5.6%	9.5%	13.2%	12.5%	7.7%	9.6%	8.6%	4.9%	3.6%	1.3%	0.2%	0.5%	-0.4%	2.2%	4.4%
Average Age (Years)															
Real Estate	8.6	8.9	9.1	9.0	9.0	9.1	9.2	9.5	10.0	10.6	11.3	11.4	11.8	11.9	12.3
Road Vehicles	2.8	2.7	2.7	2.7	2.8	2.9	3.0	3.0	3.1	3.3	3.4	3.2	3.1	3.3	3.5
Metal Goods	7.2	7.2	6.9	6.6	6.8	6.7	6.8	6.8	6.9	7.0	7.1	6.9	6.7	6.8	6.9
Plant	3.1	2.9	2.6	2.5	2.7	2.7	2.7	2.9	3.0	3.2	3.4	3.4	3.3	3.4	3.6
Mech. Engineering	5.7	5.6	5.3	5.1	5.2	5.2	5.3	5.5	5.7	6.1	6.4	6.6	6.8	7.0	7.3
Elec. Engineering	6.9	6.8	6.6	6.4	6.5	6.5	6.6	6.9	7.2	7.7	8.2	8.7	9.3	9.6	9.6

Table A2.2.4: Capital Invested for Construction

Table A2.2.4C: Construction 1977-1990														
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Investment (£M)														
Real Estate	39	39	46	38	51	60	65	56	65	45	103	126	155	175
Road Road Vehicles	162	178	224	139	192	229	247	218	267	264	306	442	427	450
Metal Goods	26	34	40	39	28	37	39	37	35	35	42	70	64	65
Plant	119	149	170	175	132	185	207	206	217	222	262	439	403	407
Mech. Engineering	50	67	82	72	47	56	53	43	30	30	36	60	55	56
Elec. Engineering	11	17	24	21	14	16	15	12	12	12	15	25	23	23
Total	407	484	586	484	464	583	626	573	626	609	763	1161	1127	1176
Capital Stock (£M)														
Real Estate	1067	1226	1452	1875	2079	2043	2046	2074	2172	2266	2401	2650	3100	3416
Road Road Vehicles	781	910	1038	1117	1152	1237	1253	1283	1378	1458	1576	1777	1958	2127
Metal Goods	264	311	364	423	463	507	544	571	603	619	644	689	735	796
Plant	696	763	840	920	931	981	1030	1057	1103	1121	1181	1394	1547	1703
Mech. Engineering	580	655	743	830	875	917	937	934	929	901	885	884	890	913
Elec. Engineering	107	129	158	188	207	227	241	248	259	263	271	285	300	321
Total	3496	3993	4597	5353	5707	5912	6051	6168	6445	6627	6959	7679	8529	9276
Capital Growth (%)														
Real Estate	1.7%	1.2%	1.2%	0.0%	0.5%	1.0%	1.2%	0.7%	1.0%	0.0%	2.4%	2.9%	3.2%	3.3%
Road Vehicles	0.9%	-0.5%	2.0%	-8.6%	-4.0%	-1.8%	-0.4%	-3.6%	-0.8%	-2.3%	-0.7%	6.5%	2.3%	1.5%
Metal Goods	5.2%	6.5%	6.8%	4.6%	1.1%	2.4%	2.4%	1.6%	0.8%	0.8%	1.6%	5.7%	4.1%	3.4%
Plant	-3.4%	-0.5%	0.3%	-1.3%	-6.7%	-1.4%	0.1%	-0.6%	-0.4%	-0.3%	2.8%	16.7%	8.2%	5.2%
Mech. Engineering	0.7%	2.5%	3.3%	0.8%	-2.8%	-2.0%	-2.5%	-3.5%	-5.0%	-4.8%	-4.1%	-1.3%	-1.9%	-2.0%
Elec. Engineering	5.5%	9.4%	11.8%	7.0%	1.7%	2.3%	1.3%	-0.1%	-0.3%	-0.3%	0.4%	4.0%	2.7%	2.3%
Average Age (Years)														
Real Estate	12.8	13.4	13.9	14.6	15.3	15.8	16.2	16.8	17.3	17.9	18.1	18.2	18.2	18.2
Road Vehicles	3.6	3.7	3.7	4.1	4.2	4.3	4.2	4.3	4.3	4.3	4.3	4.0	3.9	3.9
Metal Goods	7.1	7.2	7.3	7.6	8.0	8.4	8.7	9.1	9.5	9.9	10.2	10.1	10.1	10.2
Plant	3.8	3.9	3.9	3.9	4.2	4.3	4.2	4.2	4.2	4.1	4.0	3.4	3.3	3.3
Mech. Engineering	7.6	7.7	7.7	8.0	8.5	8.9	9.4	9.9	10.5	11.1	11.6	11.8	12.0	12.2
Elec. Engineering	9.6	9.2	8.6	8.6	8.9	9.2	9.6	10.1	10.5	11.0	11.4	11.3	11.4	11.5

Table A2.2.4: Capital Invested for Construction

Table A2.2.5A: Distribution. Transportation, and Communication 1947-1961

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Investment (£M)															
Real Estate		37	48	59	63	73	80	84	83	105	130	157	176	189	195
Road Vehicles		45	52	57	54	50	58	67	82	95	93	104	114	129	140
Railway		28	29	31	33	27	36	47	55	65	89	85	96	92	81
Ships		86	80	74	59	57	91	91	84	115	151	159	175	178	144
Aircraft		8	12	8	7	8	10	10	19	27	46	36	25	43	33
Metal Goods		15	15	16	18	20	25	27	32	33	37	36	43	46	54
Plant		5	5	6	6	7	9	10	11	12	13	13	15	17	19
Mech. Engineering		7	7	7	8	9	11	12	15	15	17	16	19	21	25
Elec. Engineering		39	39	43	47	53	65	72	85	87	97	95	113	123	144
Total		269	286	302	295	305	385	421	466	554	672	701	776	838	835
Capital Stock (£M)															
Real Estate	1835	1871	1883	1903	2156	2390	2438	2471	2673	2819	3004	3192	3249	3377	3544
Road Vehicles	214	211	222	268	278	298	284	290	312	365	395	425	445	474	526
Railway	153	157	166	182	186	209	236	253	275	310	382	422	462	490	504
Ships	639	666	695	744	722	803	907	930	940	1001	1154	1236	1311	1373	1398
Aircraft	42	43	50	53	52	59	66	68	78	96	137	157	161	182	190
Metal Goods	325	329	333	341	367	405	423	430	461	497	526	549	567	590	634
Plant	20	20	22	24	27	31	34	37	43	48	53	56	61	66	74
Mech. Engineering	78	80	81	84	91	102	108	112	123	135	145	153	161	171	187
Elec. Engineering	653	670	687	714	777	869	920	948	1030	1123	1203	1269	1326	1393	1511
Total	3958	4046	4139	4314	4656	5167	5418	5542	5935	6394	7000	7459	7744	8117	8567

Table A2.2.5: Capital Investment for Distribution, Transportation, and Communication

Table A2.2.5A: Distribution, Transportation, and Communication 1947-1961 (Cont)

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Capital Growth (%)															
Real Estate	-	1.7%	0.6%	1.1%	0.9%	1.1%	1.3%	1.4%	1.1%	1.8%	2.4%	3.1%	3.6%	3.8%	3.7%
Road Vehicles	-	-1.5%	4.4%	1.6%	-0.7%	-3.9%	0.5%	4.0%	8.6%	8.1%	4.6%	5.9%	7.6%	9.9%	9.0%
Railway	-	2.3%	3.0%	2.4%	3.3%	-2.4%	0.3%	4.4%	6.2%	7.5%	10.8%	6.4%	7.3%	4.6%	1.3%
Ships	-	3.8%	1.7%	-0.1%	-2.0%	-3.1%	0.0%	-0.2%	-1.2%	1.7%	3.6%	3.3%	3.9%	3.4%	0.3%
Aircraft	-	2.9%	12.0%	0.0%	-1.8%	-1.6%	0.1%	-0.3%	12.4%	18.0%	27.8%	10.3%	0.6%	11.3%	2.9%
Metal Goods	-	0.9%	-0.6%	-0.2%	-0.2%	0.0%	0.9%	1.5%	2.1%	1.8%	2.1%	1.7%	2.7%	3.1%	3.9%
Plant	-	2.8%	5.1%	6.1%	4.7%	4.3%	7.6%	8.3%	9.2%	6.0%	6.2%	3.6%	6.9%	7.2%	8.7%
Mech. Engineering	-	1.4%	0.1%	0.9%	0.9%	1.0%	2.6%	3.4%	4.3%	3.5%	3.9%	2.9%	4.5%	4.9%	5.9%
Elec. Engineering	-	2.3%	0.7%	1.1%	1.1%	1.2%	2.3%	2.9%	3.5%	3.0%	3.3%	2.7%	3.8%	4.2%	5.0%
Average Age (Years)															
Real Estate	26.8	26.8	27.1	27.2	27.4	27.5	27.6	27.6	27.7	27.6	27.4	27.0	26.5	26.0	25.5
Road Vehicles	4.3	4.3	4.1	4.0	4.0	4.2	4.1	3.9	3.6	3.4	3.4	3.3	3.2	3.1	3.0
Railway	4.9	4.9	4.9	4.9	4.8	5.1	5.2	5.0	4.8	4.6	4.3	4.2	4.1	4.2	4.3
Ships	6.5	6.5	6.6	6.9	7.2	7.7	7.8	7.9	8.1	8.1	7.9	7.7	7.6	7.5	7.6
Aircraft	4.8	4.8	4.4	4.6	4.8	5.0	5.1	5.2	4.7	4.1	3.4	3.4	3.7	3.6	3.8
Metal Goods	16.0	16.0	16.2	16.4	16.6	16.7	16.7	16.5	16.3	16.2	16.0	15.9	15.6	15.3	14.9
Plant	3.5	3.5	3.4	3.3	3.3	3.3	3.2	3.1	3.0	3.0	3.0	3.1	3.1	3.0	3.0
Mech. Engineering	9.7	9.7	9.9	9.9	10.0	10.0	9.8	9.6	9.4	9.2	9.1	9.0	8.8	8.6	8.3
Elec. Engineering	13.0	13.0	13.2	13.3	13.5	13.6	13.6	13.4	13.3	13.1	13.0	13.0	12.8	12.6	12.3

Table A2.2.5: Capital Investment for Distribution, Transportation, and Communication

Table A2.2.5B: Distribution, Transportation, and Communication 1962-1976

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Investment (£M)															
Real Estate	196	198	237	248	268	279	302	309	331	380	589	669	826	922	961
Road Vehicles	140	159	189	200	209	211	226	236	268	265	361	366	471	504	653
Railway	66	48	41	48	34	25	30	17	21	16	29	39	47	59	57
Ships	116	92	130	106	77	135	210	259	275	339	483	626	580	639	433
Aircraft	21	28	41	40	19	37	86	44	98	115	93	79	89	104	191
Metal Goods	55	64	72	79	84	95	118	141	183	232	308	411	449	431	498
Plant	20	23	26	28	30	34	42	41	44	45	48	51	43	49	67
Mech. Engineering	25	29	33	36	38	43	53	55	61	67	78	90	86	98	132
Elec. Engineering	146	168	190	209	221	252	312	329	378	430	514	623	619	618	744
Total	785	808	958	994	979	1111	1380	1431	1659	1889	2503	2954	3211	3423	3736
Capital Stock (£M)															
Real Estate	3816	4083	4359	4645	5003	5164	5611	6021	6651	7530	8904	11269	15349	19411	21864
Road Vehicles	564	590	664	743	806	869	943	1029	1139	1274	1433	1610	1986	2648	3180
Railway	485	458	438	430	409	381	363	355	343	329	339	349	387	436	489
Ships	1346	1298	1320	1326	1302	1333	1444	1685	1892	2166	2646	3185	3864	4632	5292
Aircraft	179	179	196	211	203	214	273	299	369	451	518	553	627	716	900
Metal Goods	674	711	762	834	907	960	1059	1190	1409	1697	2022	2480	3113	4067	5124
Plant	80	88	97	109	121	131	150	167	188	210	226	246	265	310	364
Mech. Engineering	202	216	236	262	288	309	347	387	448	518	584	669	782	982	1214
Elec. Engineering	1621	1725	1866	2055	2251	2398	2664	2965	3433	4001	4553	5282	6293	7969	9808
Total	8966	9348	9937	10615	11290	11759	12854	14099	15871	18177	21225	25643	32666	41172	48236

Table A2.2.5: Capital Investment for Distribution, Transportation, and Communication

Table A2.2.5B: Distribution, Transportation, and Communication 1962-1976 (Cont)

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Capital Growth (%)															
Real Estate	3.3%	3.0%	3.6%	3.5%	3.5%	3.6%	3.6%	3.3%	3.1%	3.2%	4.9%	4.2%	3.6%	2.9%	2.5%
Road Vehicles	6.4%	9.5%	11.8%	9.5%	8.0%	5.6%	5.2%	3.8%	4.6%	1.0%	6.9%	3.5%	4.9%	-1.2%	0.7%
Railway	-1.6%	-5.0%	-6.2%	-4.3%	-7.3%	-9.0%	-7.3%	-10.7%	-9.5%	-10.7%	-7.1%	-4.3%	-3.2%	-1.7%	-3.8%
Ships	-1.5%	-3.1%	-0.2%	-2.2%	-4.3%	0.1%	5.3%	6.3%	5.3%	6.7%	10.1%	12.0%	5.9%	4.4%	-2.0%
Aircraft	-3.7%	0.7%	7.5%	4.8%	-6.2%	2.8%	24.1%	-0.3%	15.8%	14.1%	3.6%	-0.8%	-0.9%	-0.6%	7.9%
Metal Goods	3.5%	4.3%	4.9%	5.0%	4.6%	5.5%	6.9%	7.8%	9.2%	10.0%	12.1%	13.9%	11.0%	6.2%	5.2%
Plant	6.1%	8.0%	8.7%	7.9%	6.3%	8.1%	11.2%	6.3%	4.1%	1.8%	1.6%	0.9%	-4.5%	-4.9%	-2.0%
Mech. Engineering	5.0%	6.1%	6.7%	6.5%	5.9%	6.9%	8.7%	7.1%	6.5%	5.7%	6.1%	6.3%	3.4%	2.2%	3.2%
Elec. Engineering	4.4%	5.2%	5.8%	5.8%	5.3%	6.1%	7.6%	6.8%	6.8%	6.4%	7.1%	7.7%	5.4%	3.0%	2.8%
Average Age (Years)															
Real Estate	25.1	24.8	24.4	24.1	23.7	23.4	23.1	22.9	22.7	22.5	21.9	21.6	21.3	21.3	21.3
Road Vehicles	3.0	2.9	2.8	2.8	2.8	2.9	2.9	3.0	3.1	3.2	3.2	3.2	3.2	3.4	3.5
Railway	4.6	5.0	5.5	5.7	6.2	6.7	7.1	7.7	8.2	8.7	8.9	8.8	8.6	8.3	8.2
Ships	7.9	8.2	8.3	8.6	9.0	9.0	8.5	8.1	7.8	7.4	6.9	6.3	6.2	6.2	6.6
Aircraft	4.2	4.4	4.3	4.3	4.8	4.8	4.0	4.2	3.8	3.6	3.8	4.1	4.4	4.6	4.4
Metal Goods	14.6	14.2	13.8	13.4	13.0	12.6	12.1	11.6	10.9	10.3	9.6	8.8	8.4	8.4	8.5
Plant	3.0	3.0	2.9	2.9	2.9	2.9	2.8	2.9	3.0	3.1	3.2	3.4	3.7	3.9	4.0
Mech. Engineering	8.2	8.0	7.7	7.5	7.4	7.2	7.0	6.8	6.8	6.8	6.7	6.7	6.8	7.1	7.2
Elec. Engineering	12.1	11.8	11.5	11.2	11.0	10.8	10.4	10.1	9.9	9.7	9.5	9.3	9.3	9.5	9.7

Table A2.2.5: Capital Investment for Distribution, Transportation, and Communication

Table A2.2.5C: Distribution, Transportation, and Communication 1977-1990

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Investment (£M)														
Real Estate	1169	1334	1739	1971	1873	1833	2013	2327	2635	2984	4129	5051	5956	7199
Road Vehicles	1012	1231	1539	1496	1385	1758	1658	1967	2037	2108	2548	2499	2352	2834
Railway	79	98	126	163	136	123	101	75	106	95	126	203	200	383
Ships	528	533	308	355	221	326	284	502	332	168	236	109	100	189
Aircraft	212	261	359	665	365	-6	316	668	907	511	633	834	800	1119
Metal Goods	549	640	751	824	788	765	762	807	807	878	990	1214	1332	1400
Plant	86	115	155	177	177	181	191	217	374	406	458	562	617	647
Mech. Engineering	168	225	303	354	364	383	419	494	550	598	675	828	908	946
Elec. Engineering	856	1045	1287	1626	1800	2039	2389	3014	3858	4195	4732	5801	6366	6662
Total	4659	5482	6567	7630	7109	7402	8133	10071	11606	11943	14527	17100	18631	21379
Capital Stock (£M)														
Real Estate	24136	28174	34065	45054	50610	50107	50602	52226	55687	59933	64921	73274	87401	98579
Road Vehicles	4108	5080	6083	7227	7593	8406	8492	9188	9994	10762	11927	12600	13206	14144
Railway	585	644	733	847	947	963	991	951	961	955	1002	1089	1189	1428
Ships	6318	6778	7073	7350	7673	7529	7655	7665	7629	7392	7420	7055	6882	6597
Aircraft	1142	1327	1610	2169	2442	2159	2312	2711	3345	3502	3848	4236	4646	5204
Metal Goods	6131	7062	8115	9374	10441	11371	12086	12665	13409	13847	14473	15127	16067	17381
Plant	420	486	582	693	778	846	901	961	1179	1367	1579	1840	2126	2428
Mech. Engineering	1449	1696	2015	2410	2767	3105	3414	3737	4152	4487	4906	5395	5998	6723
Elec. Engineering	11542	13135	14982	17411	19730	22082	24378	26933	30657	33847	37689	42032	47312	53719
Total	55832	64382	75257	92535	102981	106568	110832	117038	127014	136092	147766	162648	184827	206202

Table A2.2.5: Capital Investment for Distribution, Transportation, and Communication

Table A2.2.5C: Distribution, Transportation, and Communication 1977-1990 (Cont)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Capital Growth (%)														
Real Estate	3.0%	2.9%	3.3%	2.5%	1.8%	1.7%	2.1%	2.6%	2.9%	3.1%	4.7%	5.3%	5.2%	5.7%
Road Vehicles	6.2%	5.6%	7.1%	0.9%	-2.2%	1.2%	-0.6%	1.8%	0.5%	-0.5%	1.7%	-0.2%	-2.7%	0.0%
Railway	-1.7%	0.3%	2.6%	5.2%	-0.8%	-2.6%	-5.4%	-7.7%	-4.5%	-5.6%	-2.8%	4.5%	2.2%	16.1%
Ships	-1.8%	-2.3%	-5.9%	-5.4%	-7.3%	-5.9%	-6.5%	-3.7%	-5.9%	-7.9%	-7.0%	-8.6%	-8.7%	-7.3%
Aircraft	4.4%	5.8%	9.4%	22.6%	-0.1%	-15.2%	-1.5%	12.8%	16.6%	-0.5%	1.7%	5.8%	2.7%	8.3%
Metal Goods	4.3%	4.5%	4.7%	4.2%	2.8%	1.9%	1.4%	1.5%	1.1%	1.4%	2.0%	3.3%	3.6%	3.3%
Plant	0.5%	4.9%	9.1%	7.4%	3.5%	1.7%	1.5%	3.4%	17.1%	13.8%	12.7%	15.2%	12.7%	9.1%
Mech. Engineering	4.1%	6.1%	8.3%	7.8%	5.9%	5.0%	4.9%	6.0%	6.1%	6.2%	6.7%	8.7%	8.4%	7.1%
Elec. Engineering	2.6%	3.2%	3.9%	4.8%	4.5%	4.7%	5.3%	7.0%	8.7%	8.4%	8.6%	10.2%	9.8%	8.4%
Average Age (Years)														
Real Estate	21.2	21.2	21.0	21.1	21.3	21.4	21.6	21.5	21.5	21.4	20.9	20.4	20.0	19.4
Road Vehicles	3.4	3.3	3.2	3.4	3.6	3.6	3.7	3.7	3.7	3.8	3.8	3.8	4.0	4.0
Railway	8.0	7.6	7.1	6.6	6.5	6.5	6.8	7.1	7.2	7.4	7.4	6.8	6.5	5.5
Ships	7.0	7.4	8.0	8.6	9.3	9.8	10.4	10.7	11.2	11.9	12.5	13.3	14.1	14.6
Aircraft	4.4	4.3	4.2	3.6	3.9	4.9	5.1	4.6	4.1	4.3	4.5	4.4	4.5	4.3
Metal Goods	8.6	8.8	8.9	9.0	9.2	9.6	9.9	10.2	10.5	10.8	11.0	11.0	11.0	11.1
Plant	4.0	3.8	3.5	3.4	3.4	3.4	3.5	3.5	3.1	2.9	2.7	2.6	2.6	2.6
Mech. Engineering	7.2	7.1	6.9	6.8	6.7	6.8	6.8	6.8	6.8	6.7	6.7	6.5	6.4	6.3
Elec. Engineering	9.9	10.0	10.1	10.0	10.0	10.0	9.9	9.7	9.4	9.1	8.8	8.5	8.2	8.0

Table A2.2.5: Capital Investment for Distribution, Transportation, and Communication

Table A2.2.6A: Services 1947-1961	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Investment (£M)															
Real Estate		97	129	146	167	193	205	223	280	310	348	396	447	505	631
Dwellings		337	332	331	376	494	630	645	640	634	616	586	661	750	791
Road Vehicles		25	35	28	35	41	42	43	42	35	32	42	48	56	60
Metal Goods		9	10	12	15	13	11	13	17	19	21	25	27	30	34
Plant		2	2	2	3	2	2	2	3	3	4	4	5	5	6
Mech. Engineering		14	16	19	24	21	18	22	28	31	34	42	44	49	56
Elec. Engineering		14	16	19	24	21	18	22	28	31	33	41	44	49	55
Total		498	540	557	643	786	927	970	1037	1064	1087	1137	1276	1444	1633
Capital Stock (£M)															
Real Estate	2501	2596	2676	2766	3209	3642	3798	3942	4412	4789	5231	5681	5916	6310	6889
Dwellings	8675	9100	9399	9790	11617	13113	13344	13711	15027	16256	16982	17535	18184	18923	20041
Road Vehicles	131	127	138	159	168	191	187	190	192	201	199	203	206	216	236
Metal Goods	210	212	216	222	242	267	274	274	290	311	327	344	356	371	398
Plant	6	6	7	8	9	10	10	11	12	13	15	16	18	19	22
Mech. Engineering	104	111	120	133	155	180	189	196	217	243	265	292	315	342	380
Elec. Engineering	384	386	390	399	432	475	486	484	510	544	569	597	615	638	681
Total	12011	12540	12945	13478	15833	17879	18288	18808	20660	22357	23588	24669	25610	26820	28648
Capital Growth (%)															
Real Estate	-	1.8%	3.0%	3.5%	3.4%	3.5%	3.6%	3.9%	4.6%	4.8%	5.0%	5.3%	6.0%	6.5%	7.9%
Dwellings	-	2.8%	2.6%	2.5%	2.3%	2.9%	3.9%	3.9%	3.4%	3.0%	2.7%	2.4%	2.7%	3.1%	3.1%
Road Vehicles	-	-4.8%	7.2%	-2.9%	1.1%	1.9%	3.2%	3.5%	2.4%	-3.2%	-4.7%	0.8%	4.3%	8.0%	7.3%
Metal Goods	-	-1.0%	-0.4%	0.3%	1.1%	-0.1%	-0.9%	-0.1%	0.9%	1.2%	1.4%	2.6%	2.8%	3.4%	3.9%
Plant	-	-1.3%	5.7%	8.0%	10.1%	2.1%	-2.0%	1.6%	5.8%	6.1%	5.4%	9.1%	8.2%	8.6%	9.0%
Mech. Engineering	-	4.8%	6.4%	7.6%	8.8%	4.5%	1.9%	3.5%	5.4%	5.6%	5.3%	7.3%	7.1%	7.4%	7.8%
Elec. Engineering	-	-1.5%	-0.9%	-0.2%	0.5%	-0.6%	-1.3%	-0.6%	0.4%	0.8%	0.9%	2.1%	2.3%	2.9%	3.4%
Average Age (Years)															
Real Estate	25.8	25.4	25.1	24.7	24.4	24.0	23.7	23.3	22.7	22.2	21.7	21.1	20.4	19.7	18.8
Dwellings	25.7	25.3	25.4	25.5	25.6	25.6	25.4	25.1	25.0	25.0	25.1	25.2	25.2	25.2	25.2
Road Vehicles	5.2	5.2	4.6	4.6	4.4	4.3	4.1	3.9	3.9	4.0	4.2	4.1	3.9	3.7	3.5
Metal Goods	23.9	23.5	23.4	23.1	22.6	22.5	22.5	22.4	22.0	21.6	21.2	20.5	19.9	19.2	18.5
Plant	4.3	4.2	3.9	3.7	3.4	3.4	3.6	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9
Mech. Engineering	7.2	7.1	7.0	6.8	6.6	6.7	7.0	7.1	7.0	7.0	7.0	6.9	6.8	6.6	6.5
Elec. Engineering	26.9	26.4	26.3	26.0	25.5	25.3	25.3	25.1	24.7	24.3	23.8	23.1	22.3	21.5	20.7

Table A2.2.6: Capital Investment for Services

Table A2.2.6B: Services 1962-1976															
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Investment (£M)															
Real Estate	750	802	961	1019	1068	1247	1416	1501	1417	1982	2154	2771	3134	3510	3956
Dwellings	856	914	1217	1286	1374	1525	1675	1667	1643	1898	2254	3153	3786	4682	5450
Road Vehicles	53	55	67	69	71	72	81	101	114	133	121	179	202	236	425
Metal Goods	41	43	53	58	60	70	87	106	132	158	163	229	244	293	347
Plant	7	7	9	10	10	12	15	18	24	29	30	44	47	75	109
Mech. Engineering	67	70	86	94	98	115	142	157	176	187	169	204	181	225	276
Elec. Engineering	66	70	86	94	98	114	141	185	247	316	346	514	575	643	708
Total	1840	1961	2479	2629	2779	3155	3556	3736	3752	4704	5237	7093	8169	9664	11271
Capital Stock (£M)															
Real Estate	7787	8729	9772	10877	12155	13116	14901	16671	18913	22317	26795	34672	47817	61109	69760
Dwellings	21211	23064	24693	26151	28259	29426	32221	34877	38644	43489	49614	65669	86698	108294	126397
Road Vehicles	243	241	261	282	298	315	341	388	442	525	563	667	830	1132	1505
Metal Goods	430	456	496	548	601	643	718	816	973	1170	1344	1605	1968	2592	3295
Plant	25	27	31	36	40	44	51	61	77	96	112	140	174	246	345
Mech. Engineering	426	467	525	598	670	733	838	961	1134	1330	1469	1659	1907	2382	2900
Elec. Engineering	731	772	836	921	1007	1074	1194	1367	1656	2039	2404	2973	3769	5046	6447
Total	30853	33756	36614	39413	43031	45352	50264	55141	61839	70966	82301	107387	143162	180801	210649
Capital Growth (%)															
Real Estate	8.4%	7.9%	8.7%	8.1%	7.4%	8.3%	8.29%	7.7%	5.9%	7.6%	6.6%	6.5%	4.9%	4.0%	3.9%
Dwellings	3.2%	3.1%	4.1%	4.1%	4.1%	4.4%	4.43%	4.0%	3.4%	3.5%	3.7%	4.0%	3.5%	3.5%	3.5%
Road Vehicles	2.3%	3.7%	7.7%	5.9%	5.0%	3.7%	4.91%	8.2%	7.8%	7.1%	1.9%	9.3%	5.7%	1.1%	11.5%
Metal Goods	5.0%	4.9%	6.3%	6.1%	5.5%	6.6%	8.04%	9.2%	9.9%	9.9%	8.1%	10.8%	8.4%	7.1%	6.2%
Plant	11.0%	9.0%	12.0%	9.9%	7.3%	9.6%	12.34%	14.6%	15.4%	14.4%	9.8%	16.1%	9.8%	14.9%	17.0%
Mech. Engineering	9.1%	8.3%	10.1%	9.2%	7.8%	9.1%	10.72%	10.0%	8.9%	7.1%	3.9%	4.9%	1.7%	1.6%	1.7%
Elec. Engineering	4.5%	4.4%	5.9%	5.7%	5.2%	6.3%	7.70%	9.9%	11.7%	12.5%	11.0%	14.8%	12.1%	8.9%	6.7%
Average Age (Years)															
Real Estate	17.9	17.2	16.4	15.7	15.3	14.7	14.2	13.9	14.0	13.6	12.7	11.1	9.8	10.1	11.5
Dwellings	25.1	25.1	24.8	24.5	24.3	24.0	23.7	23.5	23.7	23.8	22.9	19.3	17.2	17.7	19.0
Road Vehicles	3.5	3.5	3.3	3.3	3.2	3.3	3.3	3.1	3.1	3.1	3.2	3.1	3.0	2.9	2.8
Metal Goods	17.6	16.9	16.0	15.2	14.6	13.9	13.1	12.2	11.5	10.8	10.3	9.7	9.4	9.2	9.1
Plant	2.8	2.8	2.7	2.7	2.8	2.7	2.7	2.6	2.5	2.4	2.5	2.4	2.5	2.4	2.3
Mech. Engineering	6.3	6.2	6.0	5.9	5.9	5.8	5.7	5.6	5.6	5.6	5.9	6.0	6.4	6.7	6.9
Elec. Engineering	19.7	18.9	17.8	16.9	16.2	15.4	14.4	13.3	12.2	11.1	10.4	9.4	8.8	8.6	8.5

Table A2.2.6: Capital Investment for Services

Table A2.2.6C: Services 1977-1990														
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Investment (£M)														
Real Estate	3568	3628	4375	5450	5934	6801	6745	7301	7635	8847	10962	13580	19359	20799
Dwellings	5699	6325	7649	8674	8138	8920	10447	11718	11854	13622	15274	18857	20076	18449
Road Vehicles	601	1066	1420	959	947	1117	1057	1332	1901	2102	2915	3755	4698	4111
Metal Goods	453	530	720	704	777	871	965	1119	1764	1928	2259	2561	3154	3196
Plant	168	226	345	346	392	451	513	611	995	1088	1274	1444	1779	1802
Mech. Engineering	370	446	621	586	621	667	706	779	719	786	921	1044	1286	1302
Elec. Engineering	854	923	1150	1178	1361	1593	1845	2234	2189	2394	2805	3179	3916	3967
Total	11712	13144	16279	17898	18171	20420	22279	25095	27057	30767	36410	44420	54268	53626
Capital Stock (£M)														
Real Estate	76850	89087	106589	140256	157658	157180	159166	164256	174486	187288	200936	224734	269155	302206
Dwellings	143171	162391	195522	245628	283751	298408	318361	356705	390065	421368	463094	523387	598336	648482
Road Vehicles	2067	3001	4106	4827	5094	5577	5591	6086	7172	8312	10159	12359	15344	17252
Metal Goods	4043	4765	5688	6697	7674	8666	9595	10533	12245	13772	15669	17624	20323	23409
Plant	484	653	918	1161	1400	1648	1896	2177	2819	3384	4049	4722	5653	6537
Mech. Engineering	3429	3924	4584	5263	5870	6441	6918	7352	7804	8096	8555	9008	9783	10726
Elec. Engineering	7878	9174	10716	12469	14201	16019	17798	19696	21788	23468	25656	27842	31038	34837
Total	237921	272996	328123	416302	475647	493940	519324	566806	616379	665688	728118	819677	949632	1043449
Capital Growth (%)														
Real Estate	2.8%	2.2%	2.2%	2.0%	1.8%	2.4%	2.3%	2.6%	2.5%	2.9%	3.7%	4.3%	5.6%	5.2%
Dwellings	3.1%	3.0%	3.0%	2.6%	1.9%	2.1%	2.4%	2.4%	2.1%	2.3%	2.4%	2.7%	2.4%	1.9%
Road Vehicles	12.8%	24.1%	22.3%	-0.2%	-1.7%	0.0%	-1.3%	2.4%	8.9%	7.1%	12.2%	14.9%	15.3%	5.0%
Metal Goods	7.0%	6.9%	8.8%	6.2%	5.7%	5.6%	5.6%	6.3%	11.0%	10.5%	11.0%	11.2%	12.5%	10.0%
Plant	22.5%	22.3%	28.1%	14.0%	11.2%	10.1%	9.7%	11.2%	23.6%	17.9%	16.7%	15.3%	16.7%	10.5%
Mech. Engineering	3.1%	3.8%	6.4%	3.5%	2.9%	2.6%	2.5%	2.9%	1.3%	1.9%	3.1%	4.1%	5.9%	4.7%
Elec. Engineering	6.5%	5.6%	6.4%	4.9%	5.1%	5.5%	6.0%	7.2%	5.6%	5.8%	6.7%	7.2%	8.7%	7.2%
Average Age (Years)														
Real Estate	12.7	12.8	12.4	11.1	11.4	13.0	14.2	14.9	15.4	15.2	15.2	14.4	12.9	12.7
Dwellings	20.1	20.3	19.2	17.6	17.3	18.4	18.9	18.2	18.2	17.9	17.4	16.3	15.4	15.7
Road Vehicles	2.5	2.1	2.0	2.3	2.7	2.9	3.2	3.2	3.0	2.8	2.6	2.4	2.2	2.4
Metal Goods	9.0	8.9	8.6	8.6	8.7	8.7	8.7	8.7	8.3	8.0	7.7	7.4	7.1	7.0
Plant	2.2	2.1	1.9	2.1	2.2	2.3	2.4	2.5	2.2	2.2	2.2	2.2	2.2	2.3
Mech. Engineering	7.1	7.2	7.1	7.2	7.3	7.4	7.6	7.7	7.9	8.0	8.0	8.0	7.8	7.7
Elec. Engineering	8.5	8.5	8.5	8.6	8.7	8.7	8.7	8.6	8.7	8.7	8.6	8.5	8.3	8.3

Table A2.2.6: Capital Investment for Services

Table A2.3.1A:Transfer Costs of Real Estate 1947-1961

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Investment (£M)															
Total	-	42	49	51	54	45	40	43	47	44	42	44	50	55	149
Capital Stock (£M)															
Agriculture, Forestry and Fishing	-	2	6	9	13	13	16	19	20	25	25	25	27	29	35
Energy and Water Supply	-	4	10	16	24	26	32	40	44	59	60	64	70	77	92
Manufacture	-	13	28	44	64	66	80	94	102	133	133	139	146	160	191
Construction	-	0	0	1	1	1	1	2	2	3	3	3	3	4	4
Distribution	-	9	21	32	47	48	57	67	71	91	89	93	99	108	129
Services	-	13	30	47	70	73	89	107	118	154	156	165	180	203	250
Total	-	42	95	148	218	226	276	329	357	464	466	489	524	581	702
Capital Growth (%)															
Agriculture, Forestry and Fishing	-	-	103.1%	49.0%	29.4%	20.9%	13.3%	11.1%	11.0%	5.9%	4.8%	5.1%	6.6%	6.5%	22.8%
Energy and Water Supply	-	-	108.4%	53.6%	33.6%	25.4%	18.1%	16.7%	15.6%	10.4%	9.5%	9.4%	9.6%	8.2%	23.5%
Manufacture	-	-	100.7%	48.8%	29.4%	21.7%	13.6%	11.7%	12.5%	8.6%	7.7%	6.8%	6.6%	6.9%	22.9%
Construction	-	-	117.4%	64.1%	43.1%	31.1%	23.7%	24.1%	22.5%	17.6%	13.3%	9.8%	9.9%	9.9%	25.9%
Distribution	-	-	98.1%	47.0%	28.1%	20.6%	13.0%	10.9%	10.2%	5.8%	5.9%	6.5%	7.5%	7.3%	22.4%
Services	-	-	102.9%	50.3%	31.2%	23.4%	15.5%	13.5%	14.1%	8.9%	8.5%	8.8%	10.0%	10.1%	27.3%

Table A2.3.1: Transfer Costs for Real Estate

Table A2.3.1B: Transfer Costs of Real Estate 1962-1976

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Investment (£M)															
Total	151	168	190	188	191	212	235	241	274	323	453	565	495	625	716
Capital Stock (£M)															
Agriculture, Forestry and Fishing	44	51	60	70	81	90	100	115	132	161	219	300	340	372	436
Energy and Water Supply	116	137	162	195	231	267	301	346	395	479	640	858	984	1138	1422
Manufacture	237	273	313	366	419	460	500	563	631	752	985	1300	1433	1538	1776
Construction	6	7	8	10	12	14	16	19	21	25	33	45	51	57	68
Distribution	160	186	216	254	294	328	362	411	464	560	762	1035	1168	1281	1515
Services	326	397	484	594	713	833	962	1138	1320	1659	2292	3184	3639	4034	4832
Total	889	1050	1243	1488	1749	1991	2242	2593	2963	3635	4931	6722	7614	8420	10049
Capital Growth (%)															
Agriculture, Forestry and Fishing	16.6%	15.9%	13.8%	10.2%	7.8%	7.7%	8.3%	7.1%	8.1%	7.2%	8.0%	7.6%	5.0%	4.6%	3.8%
Energy and Water Supply	17.5%	16.3%	15.7%	12.4%	11.0%	11.3%	9.6%	7.5%	7.9%	6.3%	6.3%	5.3%	6.0%	10.7%	10.5%
Manufacture	15.6%	13.6%	12.3%	9.4%	7.2%	5.7%	5.8%	5.3%	5.9%	4.4%	4.3%	3.5%	2.0%	2.8%	2.1%
Construction	17.7%	17.8%	17.5%	16.9%	13.9%	11.3%	11.8%	7.6%	6.9%	4.1%	4.1%	7.7%	4.1%	7.5%	4.6%
Distribution	15.7%	14.6%	13.6%	10.1%	8.3%	7.6%	7.5%	6.0%	6.6%	5.7%	8.3%	6.6%	4.4%	5.0%	4.5%
Services	21.5%	20.1%	19.2%	15.0%	12.4%	12.5%	12.3%	10.5%	9.5%	10.2%	9.9%	9.0%	5.7%	6.1%	5.9%

Table A2.3.1: Transfer Costs for Real Estate

Table A2.3.1C: Transfer Costs of Real Estate 1977-1990

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Investment (£M)														
Total	786	953	959	1093	1040	1299	1429	1464	1181	1196	1265	1420	1486	1475
Capital Stock (£M)														
Agriculture, Forestry and Fishing	506	645	942	1152	1293	1342	1591	1746	2041	2226	2674	3368	3732	3886
Energy and Water Supply	1735	2282	3399	4221	4862	5137	6171	6835	8120	9013	10942	13966	15710	16570
Manufacture	2032	2545	3660	4373	4809	4842	5551	5907	6814	7373	8775	11018	12237	12784
Construction	79	99	143	171	190	194	227	243	283	306	372	478	543	580
Distribution	1779	2279	3361	4107	4614	4750	5601	6124	7249	8084	10049	13213	15305	16737
Services	5664	7206	10516	12785	14373	14901	17618	19260	22714	25261	31102	40524	47132	51310
Total	11795	15057	22020	26809	30141	31166	36758	40116	47222	52263	63914	82566	94659	101867
Capital Growth (%)														
Agriculture, Forestry and Fishing	4.2%	5.6%	4.6%	4.5%	4.0%	4.8%	5.4%	5.6%	5.0%	3.4%	2.8%	2.3%	-0.7%	-1.3%
Energy and Water Supply	9.6%	9.0%	6.7%	6.1%	6.7%	6.8%	6.8%	6.6%	6.7%	5.3%	3.9%	3.7%	0.8%	0.0%
Manufacture	2.8%	3.8%	3.0%	2.1%	1.9%	1.7%	1.9%	2.4%	3.6%	2.6%	1.8%	2.0%	-0.5%	-1.0%
Construction	4.2%	4.4%	3.5%	1.9%	2.7%	3.3%	3.9%	3.3%	4.5%	2.5%	4.1%	4.4%	1.8%	1.3%
Distribution	5.5%	6.1%	5.6%	4.5%	4.1%	4.0%	4.8%	5.2%	6.4%	5.8%	6.4%	6.8%	3.8%	3.7%
Services	5.3%	5.4%	4.5%	3.9%	4.1%	4.8%	5.1%	5.2%	6.0%	5.5%	5.3%	5.8%	4.2%	3.2%

Table A2.3.1: Transfer Costs for Real Estate

Table A2.3.2A:Working Capital 1947-1961

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Stocks and work-in-progress (£M)															
Agriculture, Forestry and Fishing	648	648	678	712	746	786	821	850	882	924	1134	1172	1311	1360	1458
Energy and Water Supply	182	182	185	203	198	233	221	213	228	247	273	306	346	321	311
Manufacturing	1897	1897	2199	2329	2688	3366	3482	3680	4174	4524	4517	4461	4624	5646	5956
Construction	301	301	335	355	350	450	450	475	500	520	544	547	551	600	601
Distribution	1496	1496	1659	1782	1610	1929	1861	1970	1963	1979	1991	2013	2012	1843	1913
Services	616	616	538	478	378	580	595	462	353	342	268	261	245	210	161
Total	5140	5140	5595	5859	5970	7344	7430	7650	8100	8536	8727	8760	9089	9980	10400
Share (%)															
Agriculture, Forestry and Fishing	12.6%	12.6%	12.1%	12.2%	12.5%	10.7%	11.0%	11.1%	10.9%	10.8%	13.0%	13.4%	14.4%	13.6%	14.0%
Energy and Water Supply	3.5%	3.5%	3.3%	3.5%	3.3%	3.2%	3.0%	2.8%	2.8%	2.9%	3.1%	3.5%	3.8%	3.2%	3.0%
Manufacturing	36.9%	36.9%	39.3%	39.8%	45.0%	45.8%	46.9%	48.1%	51.5%	53.0%	51.8%	50.9%	50.9%	56.6%	57.3%
Construction	5.8%	5.8%	6.0%	6.1%	5.9%	6.1%	6.1%	6.2%	6.2%	6.1%	6.2%	6.2%	6.1%	6.0%	5.8%
Distribution	29.1%	29.1%	29.7%	30.4%	27.0%	26.3%	25.0%	25.8%	24.2%	23.2%	22.8%	23.0%	22.1%	18.5%	18.4%
Services	12.0%	12.0%	9.6%	8.2%	6.3%	7.9%	8.0%	6.0%	4.4%	4.0%	3.1%	3.0%	2.7%	2.1%	1.5%

Table A2.3.2: Working Capital

Table A2.3.2B: Working Capital 1962-1976

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Stocks and work-in-progress (£M)															
Agriculture, Forestry and Fishing	1532	1571	1640	1726	1786	1865	1947	2046	2142	2321	2318	2712	3198	3533	4308
Energy and Water Supply	324	294	308	309	332	402	401	341	317	422	447	455	601	1197	1722
Manufacturing	6058	6278	6830	7314	7704	7784	8166	9083	10019	10350	10793	13544	18621	21288	26343
Construction	599	670	781	954	938	1011	1045	1130	1202	1296	1506	1946	2611	2442	2576
Distribution	2016	2145	2342	2503	2644	2634	2996	3032	3422	3607	3930	4866	6139	7052	8301
Services	136	126	123	122	120	118	114	109	109	109	109	123	134	122	135
Total	10665	11084	12024	12928	13524	13814	14669	15741	17211	18105	19103	23646	31304	35634	43385
Share (%)															
Agriculture, Forestry and Fishing	14.4%	14.2%	13.6%	13.4%	13.2%	13.5%	13.3%	13.0%	12.4%	12.8%	12.1%	11.5%	10.2%	9.9%	9.9%
Energy and Water Supply	3.0%	2.7%	2.6%	2.4%	2.5%	2.9%	2.7%	2.2%	1.8%	2.3%	2.3%	1.9%	1.9%	3.4%	4.0%
Manufacturing	56.8%	56.6%	56.8%	56.6%	57.0%	56.3%	55.7%	57.7%	58.2%	57.2%	56.5%	57.3%	59.5%	59.7%	60.7%
Construction	5.6%	6.0%	6.5%	7.4%	6.9%	7.3%	7.1%	7.2%	7.0%	7.2%	7.9%	8.2%	8.3%	6.9%	5.9%
Distribution	18.9%	19.4%	19.5%	19.4%	19.6%	19.1%	20.4%	19.3%	19.9%	19.9%	20.6%	20.6%	19.6%	19.8%	19.1%
Services	1.3%	1.1%	1.0%	0.9%	0.9%	0.9%	0.8%	0.7%	0.6%	0.6%	0.6%	0.5%	0.4%	0.3%	0.3%

Table A2.3.2: Working Capital

Table A2.3.2C: Working Capital 1977-1990

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Stocks and work-in-progress (£M)														
Agriculture, Forestry and Fishing	5299	5913	3802	4345	4528	5032	3531	3688	3686	3578	3584	3413	3645	3692
Energy and Water Supply	1815	2016	3087	4050	5226	6173	6464	6025	5802	4742	4644	4591	5039	5173
Manufacturing	27879	30182	36406	37099	38266	36567	38413	41357	41776	42688	43929	47138	49547	52650
Construction	3057	4170	5223	5385	5272	5368	5437	5754	6502	7264	8173	9793	11237	13730
Distribution	10844	12865	15680	15874	18152	23947	25697	28042	29559	31221	33603	37254	41370	45794
Services	195	252	773	1154	838	1399	1787	1774	2471	2239	2380	3732	5098	3177
Total	49089	55398	64971	67907	72282	78486	81328	86639	89796	91732	96312	105920	115936	124216
Share (%)														
Agriculture, Forestry and Fishing	10.8%	10.7%	5.9%	6.4%	6.3%	6.4%	4.3%	4.3%	4.1%	3.9%	3.7%	3.2%	3.1%	3.0%
Energy and Water Supply	3.7%	3.6%	4.8%	6.0%	7.2%	7.9%	7.9%	7.0%	6.5%	5.2%	4.8%	4.3%	4.3%	4.2%
Manufacturing	56.8%	54.5%	56.0%	54.6%	52.9%	46.6%	47.2%	47.7%	46.5%	46.5%	45.6%	44.5%	42.7%	42.4%
Construction	6.2%	7.5%	8.0%	7.9%	7.3%	6.8%	6.7%	6.6%	7.2%	7.9%	8.5%	9.2%	9.7%	11.1%
Distribution	22.1%	23.2%	24.1%	23.4%	25.1%	30.5%	31.6%	32.4%	32.9%	34.0%	34.9%	35.2%	35.7%	36.9%
Services	0.4%	0.5%	1.2%	1.7%	1.2%	1.8%	2.2%	2.0%	2.8%	2.4%	2.5%	3.5%	4.4%	2.6%

Table A2.3.2: Working Capital

A2.4: Capital matrix

Tables:

Table A2.4.1: Initial capital matrix 1948
Table A2.4.2: Capital matrix 1947-90

Notes:

The initial capital vector for 1948 is disaggregated into a matrix. This was accomplished using the *'industry-by-industry'* and the *'asset-by-asset'* figues given in Feinstein (1972) as column and row control totals. The disaggregation was estimated, having regard to the investment totals in subsequent years to ensure maximum stability in the capital matrix and also to balance with the control totals.

Subsequent capital matrices are taken using the output of the industry capital figures with the addition of the transfer costs given in Table A2.3.1 to the real estate total and the inclusion of the working capital column.

A2.5: Price deflators

Table A2.5A: Price deflators 1948-61
Table A2.5B: Price deflators 1962-76
Table A2.5C: Price deflators 1977-90

Notes:

Deflators fully articulated into asset type and industrial group are not available. Thus the calculation are based on the assumption of the same level of price increase for given asset types regardless of the industry responsible.

A2.6: Plant and equipment investment

Table:

Table A2.6: Plant and equipment investment breakdowns 1948-90

Notes:

The above were estimated from the Benchmark Input-output tables from 1968, 1974, 1979, 1984, and also from the 1985 updated tables. Years prior to 1968 used 1968 figures, years subsequent to 1985 relied on the 1985 figures, while intermediate figures were interpolated.

Table 2.4.1A: Initial Capital Matrix 1948 £M *

	Agriculture, Forestry & Fishing	Energy & Water Supply	Manufacture	Construction	Transport, Distribution, & Communication	Services	Total §
Real Estate	491	847	2470	24	1871	2596	8300
Dwellings	-	-	-	-	-	9100	9100
Vehicles	88	14	78	24	1077	127	1408
Plant and Equipment	327	1014	1791	46	1099	716	4992
Total §	905	1875	4339	95	4046	12540	23800

* Net reproducible capital stock at current prices

§ Row and column totals obtained directly from or derived from Feinstein (1972)

Table 2.4.1B: Expanded Initial Capital Matrix 1948 £M *

	Agriculture, Forestry & Fishing	Energy & Water Supply	Manufacture	Construction	Transport, Distribution, & Communication	Services	Total
Real Estate	491	847	2470	24	1871	2596	8300
Dwellings	-	-	-	-	-	9100	9100
Road Vehicles	88	14	78	24	211	127	542
Railway Rolling Stock	-	-	-	-	157	-	157
Ships	-	-	-	-	666	-	666
Aircraft	-	-	-	-	43	-	43
Metal Goods etc.	95	392	710	5	329	212	1743
Plant	189	35	64	23	20	6	337
Mechanical Engineering	33	166	847	16	80	111	1253
Electrical Engineering	10	421	169	3	670	386	1659
Total	905	1875	4339	95	4046	12540	23800

* Net reproducible capital stock at current prices

Table 2.4.1: Initial Capital Matrix 1948

1947	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	469	0	85	0	0	0	94	189	34	9	648	1528
Energy	798	0	14	0	0	0	364	34	165	388	182	1945
Manufacture	2393	0	70	0	0	0	664	52	802	159	1897	6037
Construction	21	0	22	0	0	0	4	21	14	2	301	385
Distribution	1835	0	214	153	639	42	329	20	78	653	1496	5458
Services	2501	8675	131	0	0	0	210	6	104	384	616	12627
Total	8017	8675	535	153	639	42	1665	323	1196	1595	5140	27981
1948	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	493	0	88	0	0	0	95	189	33	10	648	1556
Energy	851	0	14	0	0	0	392	35	166	421	182	2061
Manufacture	2483	0	78	0	0	0	710	64	847	169	1897	6249
Construction	24	0	24	0	0	0	5	23	16	3	301	395
Distribution	1881	0	211	157	666	43	329	20	80	670	1496	5552
Services	2610	9100	127	0	0	0	212	6	111	386	616	13169
Total	8342	9100	542	157	666	43	1743	337	1253	1659	5140	28982
1949	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	512	0	92	0	0	0	96	196	33	10	678	1616
Energy	907	0	16	0	0	0	427	39	171	463	185	2208
Manufacture	2546	0	91	0	0	0	770	82	916	183	2199	6788
Construction	27	0	31	0	0	0	5	25	18	3	335	445
Distribution	1904	0	222	166	695	50	333	22	81	687	1659	5820
Services	2706	9399	138	0	0	0	216	7	120	390	538	13513
Total	8602	9399	589	166	695	50	1848	371	1339	1736	5595	30390
1950	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	528	0	107	0	0	0	98	204	33	10	712	1692
Energy	963	0	19	0	0	0	472	44	178	515	203	2395
Manufacture	2620	0	117	0	0	0	850	104	1010	202	2329	7233
Construction	31	0	38	0	0	0	6	28	20	4	355	482
Distribution	1936	0	268	182	744	53	341	24	84	714	1782	6129
Services	2813	9790	159	0	0	0	222	8	133	399	478	14002
Total	8890	9790	709	182	744	53	1990	412	1458	1844	5859	31933

Table 2.4.2: Capital Matrix 1947-90

1951	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	606	0	106	0	0	0	105	222	35	11	746	1832
Energy	1143	0	20	0	0	0	544	51	195	597	198	2748
Manufacture	3012	0	131	0	0	0	991	134	1178	235	2688	8368
Construction	39	0	45	0	0	0	7	34	24	4	350	503
Distribution	2203	0	278	186	722	52	367	27	91	777	1610	6313
Services	3279	11617	168	0	0	0	242	9	155	432	378	16280
Total	10282	11617	747	186	722	52	2256	477	1678	2056	5970	36045
1952	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	673	0	120	0	0	0	115	240	38	12	786	1983
Energy	1316	0	21	0	0	0	642	60	219	708	233	3200
Manufacture	3365	0	152	0	0	0	1167	165	1383	276	3366	9874
Construction	47	0	54	0	0	0	8	41	29	5	450	634
Distribution	2438	0	298	209	803	59	405	31	102	869	1929	7144
Services	3715	13113	191	0	0	0	267	10	180	475	580	18531
Total	11555	13113	836	209	803	59	2605	547	1950	2346	7344	41367
1953	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	691	0	112	0	0	0	117	241	38	12	821	2032
Energy	1408	0	19	0	0	0	712	67	233	788	221	3449
Manufacture	3464	0	148	0	0	0	1273	183	1502	301	3482	10354
Construction	53	0	54	0	0	0	9	44	32	6	450	647
Distribution	2495	0	284	236	907	66	423	34	108	920	1861	7336
Services	3887	13344	187	0	0	0	274	10	189	486	595	18972
Total	11998	13344	804	236	907	66	2809	580	2102	2513	7430	42790
1954	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	705	0	108	0	0	0	116	241	37	12	850	2069
Energy	1508	0	20	0	0	0	771	74	243	857	213	3686
Manufacture	3552	0	151	0	0	0	1347	197	1583	318	3680	10828
Construction	60	0	55	0	0	0	10	49	35	7	475	692
Distribution	2539	0	290	253	930	68	430	37	112	948	1970	7579
Services	4050	13711	190	0	0	0	274	11	196	484	462	19377
Total	12413	13711	815	253	930	68	2949	609	2206	2626	7650	44231

Table 2.4.2: Capital Matrix 1947-90

1955	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	767	0	107	0	0	0	121	254	38	13	882	2182
Energy	1710	0	21	0	0	0	877	85	267	979	228	4166
Manufacture	3916	0	162	0	0	0	1491	220	1745	351	4174	12060
Construction	72	0	61	0	0	0	12	56	41	8	500	749
Distribution	2744	0	312	275	940	78	461	43	123	1030	1963	7970
Services	4529	15027	192	0	0	0	290	12	217	510	353	21131
Total	13739	15027	855	275	940	78	3252	670	2431	2890	8100	48258
1956	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	814	0	115	0	0	0	126	258	39	13	924	2289
Energy	1891	0	22	0	0	0	987	95	291	1105	247	4637
Manufacture	4259	0	185	0	0	0	1681	253	1965	396	4524	13263
Construction	85	0	71	0	0	0	13	63	46	9	520	807
Distribution	2909	0	365	310	1001	96	497	48	135	1123	1979	8464
Services	4943	16256	201	0	0	0	311	13	243	544	342	22853
Total	14901	16256	959	310	1001	96	3615	730	2719	3190	8536	52313
1957	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	856	0	119	0	0	0	130	268	39	14	1134	2560
Energy	2079	0	23	0	0	0	1082	102	311	1214	273	5085
Manufacture	4609	0	193	0	0	0	1863	286	2179	438	4517	14087
Construction	97	0	76	0	0	0	15	71	52	10	544	864
Distribution	3094	0	395	382	1154	137	526	53	145	1203	1991	9080
Services	5387	16982	199	0	0	0	327	15	265	569	268	24012
Total	16122	16982	1006	382	1154	137	3942	795	2992	3447	8727	55687
1958	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	898	0	123	0	0	0	133	286	40	14	1172	2666
Energy	2267	0	23	0	0	0	1174	109	330	1321	306	5531
Manufacture	4908	0	209	0	0	0	2021	310	2357	475	4461	14741
Construction	106	0	82	0	0	0	17	79	58	11	547	900
Distribution	3285	0	425	422	1236	157	549	56	153	1269	2013	9565
Services	5847	17535	203	0	0	0	344	16	292	597	261	25096
Total	17311	17535	1065	422	1236	157	4239	857	3231	3686	8760	58499

Table 2.4.2: Capital Matrix 1947-90

1959	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	908	0	124	0	0	0	134	301	40	14	1311	2832
Energy	2357	0	23	0	0	0	1259	117	346	1419	346	5867
Manufacture	4960	0	222	0	0	0	2127	321	2467	499	4624	15220
Construction	110	0	86	0	0	0	18	83	62	12	551	922
Distribution	3348	0	445	462	1311	161	567	61	161	1326	2012	9855
Services	6096	18184	206	0	0	0	356	18	315	615	245	26035
Total	17778	18184	1105	462	1311	161	4462	901	3392	3884	9089	60731

1960	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	939	0	128	0	0	0	135	310	40	14	1360	2926
Energy	2475	0	23	0	0	0	1337	122	360	1509	321	6148
Manufacture	5147	0	247	0	0	0	2265	343	2623	531	5646	16803
Construction	118	0	95	0	0	0	19	87	67	13	600	999
Distribution	3486	0	474	490	1373	182	590	66	171	1393	1843	10069
Services	6513	18923	216	0	0	0	371	19	342	638	210	27232
Total	18678	18923	1183	490	1373	182	4718	948	3602	4099	9980	64177

1961	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	993	0	136	0	0	0	140	325	41	15	1458	3108
Energy	2632	0	23	0	0	0	1453	131	385	1642	311	6577
Manufacture	5448	0	274	0	0	0	2502	387	2903	587	5956	18056
Construction	128	0	111	0	0	0	22	99	75	14	601	1049
Distribution	3673	0	526	504	1398	190	634	74	187	1511	1913	10609
Services	7139	20041	236	0	0	0	398	22	380	681	161	29059
Total	20012	20041	1306	504	1398	190	5148	1037	3971	4450	10400	68457

1962	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	1083	0	138	0	0	0	143	331	42	15	1532	3284
Energy	2893	0	23	0	0	0	1575	142	411	1783	324	7150
Manufacture	5893	0	279	0	0	0	2716	418	3144	636	6058	19144
Construction	140	0	118	0	0	0	23	104	81	15	599	1080
Distribution	3976	0	564	485	1346	179	674	80	202	1621	2016	11142
Services	8113	21211	243	0	0	0	430	25	426	731	136	31315
Total	22099	21211	1364	485	1346	179	5560	1101	4306	4802	10665	73115

Table 2.4.2: Capital Matrix 1947-90

1963	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	1175	0	129	0	0	0	145	343	42	15	1571	3421
Energy	3151	0	22	0	0	0	1712	157	442	1941	294	7720
Manufacture	6266	0	280	0	0	0	2859	430	3291	669	6278	20074
Construction	155	0	124	0	0	0	26	118	90	17	670	1199
Distribution	4269	0	590	458	1298	179	711	88	216	1725	2145	11679
Services	9126	23064	241	0	0	0	456	27	467	772	126	34279
Total	24142	23064	1386	458	1298	179	5908	1164	4548	5140	11084	78372

1964	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	1261	0	128	0	0	0	149	367	44	16	1640	3604
Energy	3440	0	20	0	0	0	1890	177	484	2146	308	8465
Manufacture	6638	0	306	0	0	0	3062	457	3514	717	6830	21525
Construction	172	0	140	0	0	0	30	144	105	20	781	1391
Distribution	4575	0	664	438	1320	196	762	97	236	1866	2342	12495
Services	10256	24693	261	0	0	0	496	31	525	836	123	37222
Total	26341	24693	1519	438	1320	196	6389	1274	4909	5600	12024	84702

1965	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	1352	0	132	0	0	0	156	391	46	17	1726	3820
Energy	3758	0	21	0	0	0	2114	200	537	2403	309	9343
Manufacture	7061	0	339	0	0	0	3364	504	3857	787	7314	23225
Construction	195	0	152	0	0	0	35	174	124	23	954	1657
Distribution	4898	0	743	430	1326	211	834	109	262	2055	2503	13372
Services	11471	26151	282	0	0	0	548	36	598	921	122	40129
Total	28735	26151	1669	430	1326	211	7050	1414	5423	6205	12928	91544

1966	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	1456	0	131	0	0	0	163	413	48	17	1786	4013
Energy	4165	0	24	0	0	0	2378	228	601	2706	332	10435
Manufacture	7554	0	356	0	0	0	3689	554	4226	863	7704	24946
Construction	222	0	161	0	0	0	39	190	138	26	938	1715
Distribution	5296	0	806	409	1302	203	907	121	288	2251	2644	14227
Services	12869	28259	298	0	0	0	601	40	670	1007	120	43864
Total	31561	28259	1777	409	1302	203	7777	1547	5972	6870	13524	99200

Table 2.4.2: Capital Matrix 1947-90

1967	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	1511	0	133	0	0	0	164	421	48	18	1865	4160
Energy	4467	0	27	0	0	0	2569	248	646	2927	402	11286
Manufacture	7696	0	378	0	0	0	3884	580	4441	908	7784	25672
Construction	238	0	173	0	0	0	43	210	152	28	1011	1855
Distribution	5492	0	869	381	1333	214	960	131	309	2398	2634	14721
Services	13949	29426	315	0	0	0	643	44	733	1074	118	46303
Total	33352	29426	1895	381	1333	214	8264	1635	6330	7352	13814	103995

1968	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	1656	0	139	0	0	0	172	452	50	18	1947	4434
Energy	4956	0	30	0	0	0	2764	257	687	3150	401	12246
Manufacture	8244	0	409	0	0	0	4198	623	4787	981	8166	27407
Construction	269	0	189	0	0	0	48	233	171	32	1045	1987
Distribution	5974	0	943	363	1444	273	1059	150	347	2664	2996	16213
Services	15864	32221	341	0	0	0	718	51	838	1194	114	51341
Total	36962	32221	2050	363	1444	273	8959	1766	6881	8040	14669	113627

1969	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	1801	0	144	0	0	0	180	472	52	19	2046	4714
Energy	5411	0	33	0	0	0	2949	259	720	3345	341	13058
Manufacture	8812	0	453	0	0	0	4605	687	5257	1077	9083	29973
Construction	294	0	210	0	0	0	54	249	187	35	1130	2160
Distribution	6433	0	1029	355	1685	299	1190	167	387	2965	3032	17542
Services	17810	34877	388	0	0	0	816	61	961	1367	109	56388
Total	40561	34877	2257	355	1685	299	9794	1895	7563	8808	15741	123835

1970	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	2020	0	148	0	0	0	197	517	55	21	2142	5100
Energy	6053	0	38	0	0	0	3256	268	778	3661	317	14372
Manufacture	9680	0	498	0	0	0	5265	793	6028	1232	10019	33516
Construction	326	0	226	0	0	0	64	278	211	39	1202	2347
Distribution	7115	0	1139	343	1892	369	1409	188	448	3433	3422	19757
Services	20233	38644	442	0	0	0	973	77	1134	1656	109	63268
Total	45427	38644	2493	343	1892	369	11164	2122	8654	10042	17211	138360

Table 2.4.2: Capital Matrix 1947-90

1971	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	2328	0	179	0	0	0	218	564	58	23	2321	5692
Energy	6917	0	46	0	0	0	3616	280	843	4018	422	16142
Manufacture	10863	0	569	0	0	0	6009	900	6884	1408	10350	36983
Construction	365	0	248	0	0	0	75	303	236	43	1296	2566
Distribution	8090	0	1274	329	2166	451	1697	210	518	4001	3607	22344
Services	23976	43489	525	0	0	0	1170	96	1330	2039	109	72734
Total	52540	43489	2842	329	2166	451	12785	2352	9869	11531	18105	156460

1972	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	2774	0	207	0	0	0	238	624	59	25	2318	6245
Energy	8118	0	51	0	0	0	3930	291	894	4294	447	18026
Manufacture	12503	0	629	0	0	0	6528	945	7444	1531	10793	40374
Construction	420	0	267	0	0	0	85	318	253	46	1506	2895
Distribution	9665	0	1433	339	2646	518	2022	226	584	4553	3930	25917
Services	29088	49614	563	0	0	0	1344	112	1469	2404	109	84703
	62568	49614	3149	339	2646	518	14148	2517	10704	12854	19103	178160

1973	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	3562	0	244	0	0	0	268	733	61	27	2712	7608
Energy	10203	0	56	0	0	0	4298	302	953	4613	455	20880
Manufacture	15451	0	721	0	0	0	7226	1030	8230	1698	13544	47900
Construction	540	0	319	0	0	0	101	359	282	50	1946	3597
Distribution	12304	0	1610	349	3185	553	2480	246	669	5282	4866	31544
Services	37856	65669	667	0	0	0	1605	140	1659	2973	123	110694
Total	79917	65669	3617	349	3185	553	15979	2811	11854	14644	23646	222223

1974	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	4807	0	294	0	0	0	313	850	65	31	3198	9557
Energy	13909	0	69	0	0	0	5002	343	1080	5236	601	26239
Manufacture	20261	0	892	0	0	0	8460	1212	9668	1992	18621	61108
Construction	722	0	402	0	0	0	128	427	329	56	2611	4675
Distribution	16517	0	1986	387	3864	627	3113	265	782	6293	6139	39973
Services	51456	86698	830	0	0	0	1968	174	1907	3769	134	146935
Total	107672	86698	4472	387	3864	627	18984	3271	13830	17377	31304	288487

Table A2.4.2: Capital Matrix 1947-90

1975	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	6000	0	401	0	0	0	396	1058	74	39	3533	11500
Energy	18370	0	118	0	0	0	6410	454	1367	6510	1197	34427
Manufacture	24835	0	1173	0	0	0	10682	1512	12227	2551	21288	74268
Construction	925	0	545	0	0	0	171	530	413	71	2442	5097
Distribution	20693	0	2648	436	4632	716	4067	310	982	7969	7052	49505
Services	65143	108294	1132	0	0	0	2592	246	2382	5046	122	184957
Total	135966	108294	6016	436	4632	716	24318	4111	17445	22185	35634	359754
1976	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	6731	0	461	0	0	0	494	1330	83	46	4308	13453
Energy	21955	0	144	0	0	0	8134	630	1744	7957	1722	42285
Manufacture	27408	0	1409	0	0	0	13064	1815	14971	3194	26343	88203
Construction	1047	0	636	0	0	0	219	628	502	88	2576	5696
Distribution	23378	0	3180	489	5292	900	5124	364	1214	9808	8301	58051
Services	74592	126397	1505	0	0	0	3295	345	2900	6447	135	215616
Total	155110	126397	7336	489	5292	900	30330	5111	21413	27541	43385	423304
1977	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	7372	0	555	0	0	0	591	1591	89	52	5299	15549
Energy	25275	0	161	0	0	0	9735	802	2111	9208	1815	49106
Manufacture	29605	0	1791	0	0	0	15299	2092	17581	3866	27879	98113
Construction	1146	0	781	0	0	0	264	696	580	107	3057	6631
Distribution	25915	0	4108	585	6318	1142	6131	420	1449	11542	10844	68455
Services	82514	143171	2067	0	0	0	4043	484	3429	7878	195	243780
Total	171826	143171	9463	585	6318	1142	36063	6085	25239	32653	49089	481634
1978	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	8617	0	646	0	0	0	680	1829	91	57	5913	17832
Energy	30498	0	191	0	0	0	11194	989	2478	10220	2016	57587
Manufacture	34013	0	2148	0	0	0	17263	2340	19947	4552	30182	110445
Construction	1325	0	910	0	0	0	311	763	655	129	4170	8263
Distribution	30453	0	5080	644	6778	1327	7062	486	1696	13135	12865	79526
Services	96293	162391	3001	0	0	0	4765	653	3924	9174	252	280454
Total	201199	162391	11975	644	6778	1327	41274	7060	28792	37267	55398	554106

Table A2.4.2: Capital Matrix 1947-90

1979	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	10489	0	687	0	0	0	767	1995	93	60	3802	17894
Energy	37854	0	228	0	0	0	12786	1212	2910	11255	3087	69332
Manufacture	40759	0	2463	0	0	0	19385	2609	22555	5372	36406	129550
Construction	1596	0	1038	0	0	0	364	840	743	158	5223	9963
Distribution	37425	0	6083	733	7073	1610	8115	582	2015	14982	15680	94298
Services	117105	195522	4106	0	0	0	5688	918	4584	10716	773	339411
Total	245228	195522	14605	733	7073	1610	47105	8157	32900	42544	64971	660448

1980	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	13789	0	741	0	0	0	866	2138	101	68	4345	22049
Energy	50526	0	327	0	0	0	14748	1456	3388	12642	4050	87137
Manufacture	52345	0	2903	0	0	0	21863	2898	25799	6415	37099	149322
Construction	2046	0	1117	0	0	0	423	920	830	188	5385	10909
Distribution	49161	0	7227	847	7350	2169	9374	693	2410	17411	15874	112516
Services	153042	245628	4827	0	0	0	6697	1161	5263	12469	1154	430241
Total	320907	245628	17143	847	7350	2169	53971	9267	37791	49193	67907	812173

1981	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	15482	0	747	0	0	0	950	2191	111	78	4528	24085
Energy	58189	0	290	0	0	0	16660	1684	3805	14036	5226	99890
Manufacture	57561	0	2975	0	0	0	23664	2987	28218	7309	38266	160979
Construction	2269	0	1152	0	0	0	463	931	875	207	5272	11168
Distribution	55224	0	7593	947	7673	2442	10441	778	2767	19730	18152	125747
Services	172031	283751	5094	0	0	0	7674	1400	5870	14201	838	490858
Total	360756	283751	17850	947	7673	2442	59851	9970	41645	55560	72282	912728

1982	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	15494	0	775	0	0	0	1047	2316	129	94	5032	24887
Energy	59324	0	299	0	0	0	18432	1856	4121	15421	6173	105625
Manufacture	55910	0	3176	0	0	0	25155	3023	30476	8219	36567	162526
Construction	2237	0	1237	0	0	0	507	981	917	227	5368	11474
Distribution	54857	0	8406	963	7529	2159	11371	846	3105	22082	23947	135266
Services	172082	298408	5577	0	0	0	8666	1648	6441	16019	1399	510241
Total	359904	298408	19469	963	7529	2159	65179	10671	45189	62062	78486	950019

Table A2.4.2: Capital Matrix 1947-90

1983	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	15968	0	763	0	0	0	1140	2435	154	117	3531	24107
Energy	61923	0	370	0	0	0	19946	1976	4308	16715	6464	111702
Manufacture	55697	0	3189	0	0	0	26142	3003	32401	9095	38413	167941
Construction	2273	0	1253	0	0	0	544	1030	937	241	5437	11715
Distribution	56204	0	8492	991	7655	2312	12086	901	3414	24378	25697	142129
Services	176784	318361	5591	0	0	0	9595	1896	6918	17798	1787	538728
Total	368848	318361	19658	991	7655	2312	69454	11241	48132	68343	81328	996322

1984	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	16639	0	785	0	0	0	1215	2465	182	141	3688	25115
Energy	65129	0	397	0	0	0	21000	1992	4334	17740	6025	116618
Manufacture	56287	0	3396	0	0	0	26853	3011	34577	10104	41357	175586
Construction	2317	0	1283	0	0	0	571	1057	934	248	5754	12165
Distribution	58350	0	9188	951	7665	2711	12665	961	3737	26933	28042	151203
Services	183516	356705	6086	0	0	0	10533	2177	7352	19696	1774	587839
Total	382238	356705	21135	951	7665	2711	72838	11664	51117	74863	86639	1068526

1985	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	17724	0	761	0	0	0	1258	2548	182	148	3686	26307
Energy	70493	0	433	0	0	0	22340	2133	4367	19100	5802	124667
Manufacture	59160	0	3660	0	0	0	28298	3184	37597	11767	41776	185443
Construction	2454	0	1378	0	0	0	603	1103	929	259	6502	13230
Distribution	62936	0	9994	961	7629	3345	13409	1179	4152	30657	29559	163822
Services	197200	390065	7172	0	0	0	12245	2819	7804	21788	2471	641564
Total	362745	390065	23398	961	7629	3345	78153	12967	55031	83719	89796	1107811

1986	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	18731	0	801	0	0	0	1270	2595	178	151	3578	27302
Energy	75839	0	496	0	0	0	23091	2214	4286	19961	4742	130629
Manufacture	62039	0	3880	0	0	0	28883	3226	39317	13023	42688	193057
Construction	2572	0	1458	0	0	0	619	1121	901	263	7264	14196
Distribution	68017	0	10762	955	7392	3502	13847	1367	4487	33847	31221	175397
Services	212549	421368	8312	0	0	0	13772	3384	8096	23468	2239	693189
Total	439745	421368	25708	955	7392	3502	81482	13907	57265	90714	91732	1233770

Table A2.4.2: Capital Matrix 1947-90

1987	Real Estate	Dwellings	Road Vehicles	Railway Rolling Stock	Ships	Aircraft	Metal Goods	Plant	Mechanical Engineering	Electrical Engineering	Stocks	Total
Agriculture	19950	0	840	0	0	0	1290	2648	175	154	3584	28641
Energy	81635	0	563	0	0	0	23792	2236	4214	20748	4644	137832
Manufacture	65465	0	4150	0	0	0	29812	3352	41652	14514	43929	202874
Construction	2773	0	1576	0	0	0	644	1181	885	271	8173	15503
Distribution	74970	0	11927	1002	7420	3848	14473	1579	4906	37689	33603	191418
Services	232038	463094	10159	0	0	0	15669	4049	8555	25656	2380	761600
Total	476832	463094	29215	1002	7420	3848	85680	15045	60387	99032	96312	1337867
1988	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	22043	0	858	0	0	0	1308	2808	172	158	3413	30761
Energy	91415	0	608	0	0	0	24261	2256	4106	21338	4591	148575
Manufacture	72119	0	4269	0	0	0	30575	3516	43973	16033	47138	217625
Construction	3127	0	1777	0	0	0	689	1394	884	285	9793	17950
Distribution	86487	0	12600	1089	7055	4236	15127	1840	5395	42032	37254	213114
Services	265259	523387	12359	0	0	0	17624	4722	9008	27842	3732	863933
Total	540451	523387	32472	1089	7055	4236	89583	16538	63538	107688	105920	1491957
1989	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	25046	0	914	0	0	0	1342	2972	172	164	3645	34255
Energy	105425	0	662	0	0	0	25333	2397	4098	22490	5039	165443
Manufacture	82116	0	4604	0	0	0	31965	3797	47394	17985	49547	237408
Construction	3643	0	1958	0	0	0	735	1547	890	300	11237	20309
Distribution	102706	0	13206	1189	6882	4646	16067	2126	5998	47312	41370	241502
Services	316287	598336	15344	0	0	0	20323	5653	9783	31038	5098	1001863
Total	635222	598336	36688	1189	6882	4646	95765	18493	68334	119289	115936	1700779
1990	**Real Estate**	**Dwellings**	**Road Vehicles**	**Railway Rolling Stock**	**Ships**	**Aircraft**	**Metal Goods**	**Plant**	**Mechanical Engineering**	**Electrical Engineering**	**Stocks**	**Total**
Agriculture	26772	0	952	0	0	0	1398	3111	174	172	3692	36272
Energy	114167	0	789	0	0	0	27113	2624	4199	24290	5173	178355
Manufacture	88077	0	4820	0	0	0	34036	4120	51731	20324	52650	255757
Construction	3996	0	2127	0	0	0	796	1703	913	321	13730	23586
Distribution	115316	0	14144	1428	6597	5204	17381	2428	6723	53719	45794	268734
Services	353516	648482	17252	0	0	0	23409	6537	10726	34837	3177	1097936

Table A2.4.2: Capital Matrix 1947-90

Table A2.5A: Indices for Capital Investment 1947-1961

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Real Estate	-	11.05	11.04	11.05	9.85	8.98	8.92	8.93	8.35	8.06	7.74	7.51	7.65	7.64	7.55
(Year t to t-1)	-	-	1.00	1.00	1.12	1.10	1.01	1.00	1.07	1.04	1.04	1.03	0.98	1.00	1.01
Transfer Costs	-	14.20	12.63	12.13	10.73	12.70	11.92	11.25	11.72	9.75	10.47	10.73	10.84	10.59	10.92
(Year t to t-1)	-	-	1.12	1.04	1.13	0.84	1.07	1.06	0.96	1.20	0.93	0.98	0.99	1.02	0.97
Dwellings	-	13.49	13.40	13.18	11.37	10.36	10.58	10.69	10.09	9.61	9.45	9.37	9.28	9.20	8.95
(Year t to t-1)	-	-	1.01	1.02	1.16	1.10	0.98	0.99	1.06	1.05	1.02	1.01	1.01	1.01	1.03
Road Vehicles	-	10.08	10.00	8.42	8.07	7.23	7.63	7.76	7.85	7.25	7.00	6.90	7.09	7.31	7.19
(Year t to t-1)	-	-	1.01	1.19	1.04	1.12	0.95	0.98	0.99	1.08	1.04	1.01	0.97	0.97	1.02
Rail, Ships, Aircraft	-	10.86	10.58	9.87	9.97	8.69	7.69	7.49	7.32	6.99	6.28	6.06	5.93	5.85	5.77
(Year t to t-1)	-	-	1.03	1.07	0.99	1.15	1.13	1.03	1.02	1.05	1.11	1.04	1.02	1.01	1.01
Plant and Machinery	-	9.11	8.94	8.70	8.08	7.31	7.07	7.05	6.72	6.35	6.12	5.96	5.92	5.87	5.69
(Year t to t-1)	-	-	1.02	1.03	1.08	1.11	1.03	1.00	1.05	1.06	1.04	1.03	1.01	1.01	1.03

Table A2.5: Indices for Capital Investment

Table A2.5B: Indices for Capital Investment 1962-1976

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Real Estate	7.24	6.97	6.77	6.57	6.32	6.34	6.05	5.82	5.43	4.95	4.40	3.62	2.75	2.24	2.04
(Year t to t-1)	1.04	1.04	1.03	1.03	1.04	1.00	1.05	1.04	1.07	1.10	1.13	1.21	1.32	1.23	1.10
Transfer Costs	10.17	10.04	9.82	9.20	8.61	8.29	8.06	7.53	7.12	6.24	4.97	3.90	3.61	3.45	3.05
(Year t to t-1)	1.07	1.01	1.02	1.07	1.07	1.04	1.03	1.07	1.06	1.14	1.26	1.27	1.08	1.04	1.13
Dwellings	8.72	8.27	8.04	7.91	7.62	7.64	7.28	7.00	6.53	6.01	5.46	4.29	3.36	2.79	2.47
(Year t to t-1)	1.03	1.05	1.03	1.02	1.04	1.00	1.05	1.04	1.07	1.09	1.10	1.27	1.28	1.21	1.13
Road Vehicles	7.14	7.47	7.42	7.26	7.22	7.08	6.86	6.53	6.17	5.57	5.30	4.88	4.15	3.08	2.58
(Year t to t-1)	1.01	0.96	1.01	1.02	1.01	1.02	1.03	1.05	1.06	1.11	1.05	1.09	1.18	1.35	1.19
Rail, Ships, Aircraft	5.90	5.93	5.82	5.67	5.52	5.40	5.25	4.78	4.49	4.18	3.77	3.51	3.06	2.67	2.29
(Year t to t-1)	0.98	1.00	1.02	1.03	1.03	1.02	1.03	1.10	1.07	1.07	1.11	1.07	1.15	1.15	1.17
Plant and Machinery	5.53	5.47	5.35	5.14	4.94	4.92	4.77	4.58	4.22	3.86	3.63	3.37	2.98	2.42	2.02
(Year t to t-1)	1.03	1.01	1.02	1.04	1.04	1.00	1.03	1.04	1.08	1.09	1.06	1.08	1.13	1.23	1.20

Table A2.5: Indices for Capital Investment

Table A2.5C: Indices for Capital Investment 1977-1990

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Real Estate	1.90	1.68	1.43	1.11	1.00	1.03	1.04	1.04	1.00	0.96	0.93	0.86	0.76	0.71
(Year t to t-1)	1.13	1.13	1.17	1.29	1.10	0.97	0.99	1.01	1.04	1.04	1.04	1.07	1.13	1.07
Transfer Costs	2.74	2.27	1.63	1.39	1.29	1.30	1.16	1.11	1.00	0.95	0.81	0.66	0.59	0.56
(Year t to t-1)	1.21	1.21	1.40	1.17	1.08	0.99	1.13	1.04	1.11	1.05	1.17	1.23	1.12	1.05
Dwellings	2.25	2.04	1.75	1.43	1.26	1.22	1.17	1.07	1.00	0.95	0.88	0.80	0.72	0.68
(Year t to t-1)	1.10	1.10	1.17	1.22	1.13	1.03	1.04	1.09	1.07	1.06	1.07	1.10	1.12	1.06
Road Vehicles	2.12	1.81	1.62	1.37	1.28	1.17	1.15	1.08	1.00	0.92	0.85	0.80	0.74	0.69
(Year t to t-1)	1.17	1.17	1.12	1.18	1.07	1.09	1.02	1.06	1.08	1.08	1.09	1.06	1.08	1.07
Rail, Ships, Aircraft	1.88	1.71	1.54	1.41	1.25	1.20	1.10	1.06	1.00	0.95	0.88	0.85	0.79	0.77
(Year t to t-1)	1.10	1.10	1.11	1.10	1.13	1.04	1.09	1.04	1.06	1.05	1.08	1.04	1.07	1.03
Plant and Machinery	1.76	1.60	1.46	1.31	1.21	1.13	1.08	1.05	1.00	0.98	0.96	0.95	0.92	0.88
(Year t to t-1)	1.10	1.10	1.10	1.11	1.08	1.07	1.05	1.03	1.05	1.02	1.02	1.01	1.03	1.05

Table A2.5: Indices for Capital Investment

Table A2.6: Plant and Equipment Investment Breakdown							
	Agriculture Forestry and Fishing	Energy and Water Supply	Manufacture	Construction	Distribution Transport and Commun.	Services	Average
1968							
Metal Goods etc.	0.087	0.376	0.326	0.063	0.225	0.226	0.293
Plant	0.865	0.081	0.120	0.625	0.080	0.038	0.163
Mechanical Eng	0.038	0.113	0.478	0.271	0.102	0.369	0.299
Electrical Eng	0.010	0.431	0.076	0.042	0.594	0.367	0.245
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1969							
Metal Goods etc.	0.091	0.391	0.323	0.072	0.250	0.227	0.297
Plant	0.866	0.081	0.121	0.628	0.073	0.040	0.158
Mechanical Eng	0.033	0.112	0.480	0.263	0.097	0.337	0.295
Electrical Eng	0.009	0.416	0.076	0.037	0.581	0.397	0.251
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1970							
Metal Goods etc.	0.096	0.406	0.321	0.082	0.275	0.228	0.301
Plant	0.867	0.082	0.122	0.630	0.065	0.041	0.153
Mechanical Eng	0.027	0.111	0.482	0.255	0.092	0.304	0.290
Electrical Eng	0.009	0.401	0.076	0.033	0.568	0.427	0.256
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1971							
Metal Goods etc.	0.101	0.421	0.318	0.091	0.300	0.229	0.305
Plant	0.868	0.082	0.122	0.633	0.058	0.042	0.148
Mechanical Eng	0.021	0.110	0.485	0.247	0.087	0.271	0.285
Electrical Eng	0.009	0.386	0.075	0.029	0.555	0.458	0.262
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1972							
Metal Goods etc.	0.106	0.436	0.315	0.101	0.325	0.230	0.309
Plant	0.869	0.083	0.123	0.636	0.051	0.043	0.143
Mechanical Eng	0.016	0.109	0.487	0.239	0.082	0.238	0.280
Electrical Eng	0.009	0.371	0.075	0.025	0.543	0.488	0.268
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1973							
Metal Goods etc.	0.111	0.452	0.312	0.110	0.350	0.232	0.313
Plant	0.870	0.084	0.124	0.639	0.043	0.044	0.138
Mechanical Eng	0.010	0.108	0.489	0.231	0.077	0.206	0.275
Electrical Eng	0.009	0.356	0.075	0.021	0.530	0.519	0.274
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A2.6: Plant and equipment investment breakdown

Table A2.6: Plant and Equipment Investment Breakdown (Cont)							
	Agriculture Forestry and Fishing	**Energy and Water Supply**	**Manufacture**	**Construction**	**Distribution Transport and Commun.**	**Services**	**Average**
1974							
Metal Goods etc.	0.116	0.467	0.310	0.120	0.375	0.233	0.317
Plant	0.871	0.084	0.124	0.641	0.036	0.045	0.133
Mechanical Eng	0.004	0.107	0.491	0.223	0.072	0.173	0.270
Electrical Eng	0.009	0.341	0.075	0.016	0.517	0.549	0.280
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1975							
Metal Goods etc.	0.118	0.464	0.304	0.121	0.360	0.237	0.314
Plant	0.870	0.095	0.122	0.621	0.041	0.060	0.136
Mechanical Eng	0.004	0.119	0.490	0.230	0.082	0.182	0.273
Electrical Eng	0.008	0.322	0.085	0.028	0.517	0.520	0.278
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1976							
Metal Goods etc.	0.121	0.461	0.297	0.123	0.345	0.241	0.310
Plant	0.870	0.106	0.119	0.600	0.046	0.076	0.138
Mechanical Eng	0.004	0.131	0.489	0.237	0.092	0.191	0.276
Electrical Eng	0.006	0.302	0.095	0.040	0.516	0.492	0.276
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1977							
Metal Goods etc.	0.123	0.458	0.291	0.124	0.331	0.245	0.307
Plant	0.869	0.118	0.116	0.580	0.052	0.091	0.141
Mechanical Eng	0.003	0.142	0.487	0.244	0.101	0.201	0.279
Electrical Eng	0.005	0.282	0.105	0.052	0.516	0.463	0.274
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1978							
Metal Goods etc.	0.126	0.455	0.285	0.126	0.316	0.250	0.304
Plant	0.868	0.129	0.114	0.560	0.057	0.106	0.143
Mechanical Eng	0.003	0.154	0.486	0.251	0.111	0.210	0.281
Electrical Eng	0.004	0.263	0.116	0.064	0.516	0.434	0.272
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979							
Metal Goods etc.	0.128	0.452	0.278	0.128	0.301	0.254	0.300
Plant	0.867	0.140	0.111	0.539	0.062	0.122	0.146
Mechanical Eng	0.002	0.165	0.485	0.258	0.121	0.219	0.284
Electrical Eng	0.002	0.243	0.126	0.075	0.516	0.406	0.270
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A2.6: Plant and equipment investment breakdown

Table A2.6: Plant and Equipment Investment Breakdown (Cont)							
	Agriculture Forestry and Fishing	Energy and Water Supply	Manufacture	Construction	Distribution Transport and Commun.	Services	Average
1980							
Metal Goods etc.	0.134	0.447	0.259	0.127	0.276	0.250	0.288
Plant	0.842	0.133	0.105	0.569	0.059	0.123	0.139
Mechanical Eng	0.013	0.146	0.501	0.235	0.119	0.208	0.278
Electrical Eng	0.011	0.274	0.136	0.068	0.545	0.419	0.295
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981							
Metal Goods etc.	0.140	0.441	0.239	0.126	0.252	0.247	0.276
Plant	0.817	0.126	0.098	0.599	0.057	0.125	0.133
Mechanical Eng	0.025	0.128	0.517	0.213	0.116	0.197	0.272
Electrical Eng	0.019	0.305	0.146	0.062	0.575	0.432	0.319
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1982							
Metal Goods etc.	0.146	0.435	0.219	0.125	0.227	0.243	0.263
Plant	0.791	0.120	0.092	0.630	0.054	0.126	0.126
Mechanical Eng	0.036	0.109	0.533	0.190	0.114	0.186	0.267
Electrical Eng	0.027	0.336	0.156	0.055	0.605	0.445	0.344
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1983							
Metal Goods etc.	0.152	0.430	0.199	0.125	0.203	0.239	0.251
Plant	0.766	0.113	0.085	0.660	0.051	0.127	0.120
Mechanical Eng	0.047	0.090	0.549	0.168	0.111	0.175	0.261
Electrical Eng	0.036	0.367	0.166	0.048	0.635	0.458	0.369
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1984							
Metal Goods etc.	0.158	0.424	0.180	0.124	0.178	0.236	0.239
Plant	0.740	0.107	0.079	0.690	0.048	0.129	0.113
Mechanical Eng	0.058	0.072	0.565	0.145	0.109	0.164	0.255
Electrical Eng	0.044	0.398	0.176	0.041	0.665	0.471	0.393
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1985 onwards							
Metal Goods etc.	0.090	0.407	0.192	0.118	0.144	0.311	0.251
Plant	0.884	0.131	0.080	0.740	0.067	0.176	0.134
Mechanical Eng	0.012	0.054	0.520	0.101	0.098	0.127	0.232
Electrical Eng	0.013	0.408	0.208	0.041	0.690	0.386	0.384
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000

. Table A2.6: Plant and equipment investment breakdown

APPENDIX NO 3:
DERIVATION OF ADJUSTED PROFIT VECTOR

Those of you who have had the opportunity — or misfortune — to work with national income accounts of any country will know how tenuous is the boundary between economic fact and fiction in our data.

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A3.1: Direct employment and self employment

Tables:

Table A3.1A: Employment in the UK 1948-61
Table A3.1B: Employment in the UK 1962-76
Table A3.1C: Employment in the UK 1977-90

Notes:

Total employment is presented broken down into employees in employment and self-employment within each of the six industrial groupings. For the years from 1970 onwards the number of employees for each industry was taken from the figures provided in the *Annual Abstract of Statistics*. The figure for the overall numbers of self-employed was taken from the same source and distrubuted to the six industrial groupings using the figures from the Labour Force Survey published in *Employment Gazette*.

No figures on the industrial distribution of the self-employed were published for the earlier years of the study. They were obtained indirectly as the residue between the 'total employment' figures and the 'number of employees' as published in the *Annual Abstract of Statistics*.

The figures published for employment appear to be subject to less adjustment from year to year than the national income data. Some apparent discrepancies came to light in that the figures prior to 1959 included the unemployed within the total numbers of employees within each industry while post 1959 the figures presented the number of employees in employment. The early figures once corrected by deduction of the unemployed were in line with the later figures. The only real discontinuities found in the data corresponded with changes in the SIC in 1958 and 1968 *etc*.

The wage element within value added was divided by the number of employees in employment for each year to establish the average wage level for each industry.

Table A3.1A: Employment 1947-1961															
	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Employees															
Agriculture, Forestry and Fishing	-	858	835	822	796	774	750	739	720	688	679	656	655	633	616
Energy and Water Supply	-	1149	1163	1131	1144	1171	1172	1173	1167	1164	1176	1160	1141	1074	1050
Manufacture	-	8211	8379	8602	8830	8604	8816	9050	9275	9342	9371	9206	8568	8924	9046
Construction	-	1334	1322	1326	1331	1325	1338	1359	1385	1431	1413	1374	1417	1458	1516
Distribution	-	4509	4544	4553	4569	4607	4637	4703	4762	4851	4897	4884	5046	5116	5161
Services	-	5230	5043	4995	5112	5167	5160	5209	5182	5203	5206	5133	5746	5779	5866
Total	-	21292	21285	21429	21781	21648	21873	22233	22491	22680	22743	22414	22573	22984	23255
Self-employed															
Agriculture, Forestry and Fishing	-	423	443	440	438	430	428	425	434	432	431	434	423	429	405
Energy and Water Supply	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture	-	186	178	199	202	205	223	223	224	221	195	181	166	150	136
Construction	-	116	116	109	118	110	111	132	138	147	143	154	148	149	144
Distribution	-	560	568	574	564	556	554	549	557	609	584	610	640	692	700
Services	-	363	446	466	465	457	446	450	449	422	441	439	407	355	360
Total	-	1648	1752	1787	1788	1758	1762	1779	1803	1831	1794	1817	1784	1775	1745
													1770	1767	1760
Total Employment															
Agriculture, Forestry and Fishing	-	1281	1278	1262	1234	1204	1178	1164	1154	1120	1110	1090	1078	1062	1021
Energy and Water Supply	-	1149	1163	1131	1144	1171	1172	1173	1167	1164	1176	1160	1141	1074	1050
Manufacture	-	8397	8557	8801	9032	8809	9039	9273	9499	9563	9566	9387	8734	9074	9182
Construction	-	1450	1438	1434	1449	1435	1449	1491	1523	1578	1556	1528	1565	1607	1660
Distribution	-	5069	5112	5127	5133	5163	5191	5252	5319	5460	5481	5494	5686	5808	5861
Services	-	5594	5489	5461	5577	5624	5606	5659	5632	5625	5647	5572	6153	6134	6226
Total		22940	23037	23216	23569	23406	23635	24012	24294	24510	24536	24231	24357	24759	25000
Average Wages for Employees															
Agriculture, Forestry and Fishing	-	0.30	0.32	0.32	0.34	0.36	0.39	0.40	0.42	0.46	0.48	0.52	0.52	0.54	0.55
Energy and Water Supply	-	0.40	0.41	0.44	0.49	0.54	0.57	0.60	0.64	0.70	0.75	0.77	0.77	0.82	0.87
Manufacture	-	0.27	0.28	0.30	0.33	0.36	0.38	0.40	0.43	0.46	0.49	0.52	0.59	0.62	0.65
Construction	-	0.34	0.37	0.38	0.42	0.45	0.49	0.52	0.55	0.61	0.63	0.68	0.68	0.72	0.78
Distribution	-	0.29	0.31	0.32	0.37	0.39	0.40	0.42	0.46	0.49	0.52	0.54	0.55	0.58	0.61
Services	-	0.39	0.43	0.46	0.49	0.52	0.54	0.57	0.63	0.68	0.71	0.76	0.72	0.77	0.85

Table A3.1: Employment in U.K.

Table A3.1B: Employment 1962-1976	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Employees															
Agriculture, Forestry and Fishing	580	566	539	497	475	443	423	491	466	432	427	432	414	397	393
Energy and Water Supply	1038	1021	999	978	941	920	846	842	801	773	735	707	696	705	701
Manufacture	8965	8825	8940	9098	9231	8946	8854	8356	8341	8058	7779	7830	7873	7490	7246
Construction	1552	1582	1659	1746	1725	1591	1554	1463	1339	1262	1300	1380	1329	1314	1309
Distribution	5268	5260	5283	5300	5238	5077	5022	4271	4247	4178	4183	4268	4267	4281	4198
Services	6036	6194	6284	6473	6634	6746	6807	7201	7283	7420	7695	8046	8211	8520	8715
Total	23439	23448	23704	24092	24244	23723	23506	22624	22477	22123	22119	22663	22790	22707	22562
Self-employed															
Agriculture, Forestry and Fishing	413	411	408	356	330	325	300	300	300	282	261	259	241	246	250
Energy and Water Supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture	136	135	149	113	110	120	125	125	125	126	136	131	134	139	140
Construction	145	145	143	163	166	260	275	293	300	328	377	442	423	362	341
Distribution	656	666	578	510	510	540	550	560	560	571	549	548	544	555	560
Services	359	350	418	529	577	515	600	610	620	631	610	594	593	631	600
Total	1709	1707	1696	1706	1693	1760	1850	1888	1905	1938	1933	1974	1935	1933	1891
Total Employment															
Agriculture, Forestry and Fishing	993	977	947	853	805	768	723	791	766	714	688	691	655	643	643
Energy and Water Supply	1038	1021	999	978	941	920	846	842	801	773	735	707	696	705	701
Manufacture	9101	8960	9089	9211	9341	9066	8979	8481	8466	8184	7915	7961	8007	7629	7386
Construction	1697	1727	1802	1909	1891	1851	1829	1756	1639	1590	1677	1822	1752	1676	1650
Distribution	5924	5926	5861	5810	5748	5617	5572	4831	4807	4749	4732	4816	4811	4836	4758
Services	6395	6544	6702	7002	7211	7261	7407	7811	7903	8051	8305	8640	8804	9151	9315
Total	25148	25155	25400	25798	25937	25483	25356	24512	24382	24061	24052	24637	24725	24640	24453
Average Wages for Employees															
Agriculture, Forestry and Fishing	0.59	0.62	0.65	0.72	0.77	0.83	0.88	0.78	0.88	1.08	1.07	1.42	1.76	2.08	2.44
Energy and Water Supply	0.91	0.95	1.00	1.06	1.15	1.19	1.28	1.30	1.46	1.55	2.00	2.25	2.83	4.21	4.77
Manufacture	0.68	0.71	0.76	0.82	0.86	0.89	0.97	1.13	1.29	1.44	1.70	1.96	2.27	3.04	3.55
Construction	0.85	0.86	0.91	0.93	0.97	1.08	1.16	1.27	1.41	1.76	1.73	2.00	2.44	3.11	3.48
Distribution	0.63	0.67	0.70	0.75	0.81	0.86	0.93	1.15	1.30	1.48	1.85	2.11	2.52	3.26	3.72
Services	0.88	0.93	1.01	1.06	1.13	1.21	1.30	1.30	1.44	1.66	1.64	1.82	2.20	2.81	3.14

Table A3.1: Employment in U.K.

Table A3.1C: Employment 1978-1990														
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Employees														
Agriculture, Forestry and Fishing	388	395	380	373	363	358	350	340	341	329	321	313	300	298
Energy and Water Supply	697	717	722	726	710	680	649	616	591	544	508	486	465	452
Manufacture	7292	7281	7253	6937	6222	5863	5525	5409	5362	5228	5152	5195	5187	5151
Construction	1270	1199	1239	1243	1130	1067	1044	1037	1021	987	1009	1047	1082	1087
Distribution	4221	5557	5736	5809	5597	5518	5463	5584	5622	5596	5596	5815	6092	6198
Services	8749	7958	8157	8225	8204	8253	8359	8578	8812	9025	9317	9719	9842	9974
Total	22617	23107	23487	23313	22226	21739	21390	21564	21749	21709	21903	22575	22968	23160
Self-employed														
Agriculture, Forestry and Fishing	252	254	254	250	250	250	272	275	275	273	270	268	266	265
Energy and Water Supply	0	0	0	1	1	1	1	1	1	1	1	2	2	2
Manufacture	146	145	142	147	149	150	152	183	208	211	248	259	282	285
Construction	291	365	343	375	388	400	417	472	478	495	550	601	730	608
Distribution	560	555	551	750	797	800	810	930	912	910	979	982	1003	1000
Services	596	575	554	500	476	500	569	634	736	736	813	874	855	850
Total	1845	1894	1844	2023	2061	2101	2222	2496	2610	2627	2862	2987	3139	3010
Total Employment														
Agriculture, Forestry and Fishing	640	649	634	623	613	608	622	615	616	602	591	581	566	563
Energy and Water Supply	697	717	722	727	711	681	650	617	592	545	509	488	467	454
Manufacture	7438	7426	7395	7084	6371	6013	5677	5592	5570	5439	5400	5454	5469	5436
Construction	1561	1564	1582	1618	1518	1467	1461	1509	1499	1482	1559	1648	1812	1695
Distribution	4781	6112	6287	6559	6394	6318	6273	6514	6534	6506	6575	6797	7095	7198
Services	9345	8533	8711	8725	8680	8753	8928	9212	9548	9761	10130	10593	10697	10824
Total	24462	25001	25331	25336	24287	23840	23612	24060	24359	24336	24765	25562	26107	26170
Average Wages for Employees														
Agriculture, Forestry and Fishing	2.40	2.57	3.07	3.89	4.31	4.72	5.22	5.56	5.93	6.16	6.36	6.88	7.57	8.28
Energy and Water Supply	5.23	6.03	7.19	9.05	10.27	11.34	11.85	9.84	13.17	14.75	13.85	16.58	18.59	20.72
Manufacture	3.97	4.56	5.33	6.23	7.16	7.86	8.52	9.24	9.97	10.79	11.59	12.30	13.41	14.88
Construction	3.90	4.72	5.32	6.14	6.93	7.60	8.31	8.81	9.24	10.08	10.81	11.90	13.27	14.90
Distribution	4.25	3.69	4.29	4.96	5.66	6.06	6.56	6.95	7.33	7.85	8.44	8.91	9.89	10.99
Services	3.44	4.29	4.87	6.31	6.93	7.49	8.22	8.77	9.28	10.13	10.92	11.82	13.05	10.47

Table A3.1: Employment in U.K.

A3.2: Adjusted profits

Tables:

Table A3.2A: Profits in the UK 1948-61
Table A3.2A: Profits in the UK 1962-76
Table A3.2A: Profits in the UK 1977-90

Notes:

The adjusted profit figures are derived from the published tables containing estimates of corporate profits and payments to the self-employed. It is assumed that there is a notional 'wage' element within the payments to the self-employed corresponding to the rewards for labour rather than that accruing to capital or entrepreneurship *etc.* and that this will roughly equate to the average wage level for the industry in question. The numbers of the self-employed and the average annual wage levels are taken from Tables A3.1A-C and used to compute this notional 'wage' element which is deducted from the raw figures for profits *etc.* to give the adjusted totals for profits.

Table A3.2A: Profits 1947-1961															
	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Value Added (£M)															
Agriculture, Forestry and Fishing	-	645	693	686	726	770	786	777	801	825	863	872	877	912	982
Energy and Water Supply	-	594	621	664	723	812	879	934	990	1124	1184	1238	1260	1304	1378
Manufacture	-	3539	3733	4169	4725	4738	5116	5618	6168	6515	6888	7006	7509	8239	8498
Construction	-	570	617	639	699	752	830	893	977	1100	1127	1180	1236	1363	1523
Distribution	-	2307	2437	2614	2950	2940	3034	3250	3568	3833	4020	4032	4256	4709	4895
Services	-	2869	3024	3211	3442	3623	3821	4163	4510	4847	5087	5467	5884	6359	6990
Total	-	10524	11125	11983	13265	13635	14466	15635	17014	18244	19169	19795	21022	22886	24266
Raw Profit (£M)															
Agriculture, Forestry and Fishing	-	387	425	422	454	491	497	481	497	508	536	534	538	571	643
Energy and Water Supply	-	129	142	161	161	175	214	233	239	306	306	348	383	427	469
Manufacture	-	1304	1351	1591	1844	1611	1755	1991	2163	2174	2278	2226	2462	2742	2614
Construction	-	117	134	132	141	152	177	191	209	231	230	250	270	311	339
Distribution	-	986	1024	1136	1279	1164	1178	1262	1391	1449	1463	1383	1493	1760	1761
Services	-	835	844	928	937	935	1026	1193	1271	1314	1398	1584	1769	1901	2032
Total	-	905	931	969	1070	1180	1191	1196	1276	1410	1409	1476	1502	1545	1650
Self-employed Wages (£M)															
Agriculture, Forestry and Fishing	-	127	142	141	150	155	165	170	183	199	208	224	219	231	223
Energy and Water Supply	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture	-	51	51	60	66	75	85	89	97	102	96	94	98	92	88
Construction	-	39	42	42	49	50	54	68	77	89	91	104	101	107	112
Distribution	-	164	177	186	206	214	222	232	255	299	305	331	350	399	425
Services	-	141	193	213	228	238	242	256	281	286	313	332	291	274	304
Total		523	605	642	699	731	767	816	892	977	1011	1084	1060	1104	1153
Adjusted Profits (£M)															
Agriculture, Forestry and Fishing	-	260	283	281	304	336	332	311	314	309	328	310	319	340	420
Energy and Water Supply	-	129	142	161	161	175	214	233	239	306	306	348	383	427	469
Manufacture	-	1253	1300	1531	1778	1536	1670	1902	2066	2072	2182	2132	2364	2650	2526
Construction	-	78	92	90	92	102	123	123	132	142	139	146	169	204	227
Distribution	-	822	847	950	1073	950	956	1030	1136	1150	1158	1052	1143	1361	1336
Services	-	694	651	715	709	697	784	937	990	1028	1085	1252	1478	1627	1728
Total															

Table A3.2: Profits for U.K.

Table A3.2B: Profits 1962-1976															
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Value Added (£M)															
Agriculture, Forestry and Fishing	1005	1000	1023	1062	1092	1141	1164	1235	1344	1494	1654	2232	2407	2774	3537
Energy and Water Supply	1487	1587	1668	1726	1788	1856	1994	2034	2115	2283	2805	3189	3791	5407	7155
Manufacture	8605	9084	10021	10821	11240	11302	12343	13172	14816	16307	18652	22333	26047	30657	35577
Construction	1674	1771	2013	2164	2270	2393	2596	2746	2874	3513	4050	5146	5775	6695	7495
Distribution	5125	5460	5844	6288	6610	6797	7363	7703	8342	9673	12374	14682	17269	21172	23795
Services	7459	8127	8772	9489	10355	11325	13523	14465	16277	17470	18046	21237	25595	33558	38922
Total	25355	27029	29341	31550	33355	34814	38983	41355	45768	50740	57581	68819	80884	100263	116481
Raw Profit (£M)															
Agriculture, Forestry and Fishing	664	649	670	702	728	774	790	850	932	1029	1197	1620	1677	1949	2577
Energy and Water Supply	546	617	665	688	705	759	914	940	943	1084	1335	1601	1818	2442	3812
Manufacture	2547	2856	3221	3390	3322	3301	3754	3718	4040	4677	5436	6990	8212	7884	9850
Construction	358	417	506	548	597	677	800	893	992	1293	1799	2386	2534	2608	2935
Distribution	1802	1956	2130	2307	2363	2407	2672	2797	2823	3478	4633	5694	6533	7234	8185
Services	2132	2339	2430	2635	2845	3178	4696	5075	5777	5119	5419	6609	7531	9652	11591
Total	8049	8834	9622	10270	10560	11096	13626	14273	15507	16680	19819	24900	28305	31769	38950
Self-employed Wages (£M)															
Agriculture, Forestry and Fishing	243	255	267	258	253	269	265	235	265	304	279	367	425	511	611
Energy and Water Supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture	92	95	113	92	94	107	121	141	161	182	231	257	304	423	497
Construction	123	124	130	151	161	280	318	371	422	577	653	884	1032	1126	1188
Distribution	414	444	406	383	414	467	514	643	728	847	1016	1154	1369	1807	2082
Services	317	327	422	560	653	622	778	795	894	1050	1001	1080	1305	1771	1882
Total	1188	1245	1339	1444	1575	1746	1996	2186	2470	2959	3180	3742	4433	5637	6260
Adjusted Profits (£M)															
Agriculture, Forestry and Fishing	421	394	403	444	475	505	525	615	667	725	918	1253	1252	1438	1966
Energy and Water Supply	546	617	665	688	705	759	914	940	943	1084	1335	1601	1818	2442	3812
Manufacture	2455	2761	3108	3298	3228	3194	3633	3577	3879	4495	5205	6733	7908	7461	9353
Construction	235	293	376	397	436	397	482	522	570	716	1146	1502	1502	1482	1747
Distribution	1388	1512	1724	1924	1949	1940	2158	2154	2095	2631	3617	4540	5164	5427	6103
Services	1815	2012	2008	2075	2192	2556	3918	4280	4883	4069	4418	5529	6226	7881	9709
Total	6861	7589	8283	8826	8985	9350	11630	12087	13037	13721	16639	21158	23872	26132	32690

Table A3.2: Profits for U.K.

Table A3.2C: Profits 1977-1990														
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Value Added (£M)														
Agriculture, Forestry and Fishing	3511	3532	3965	4589	5147	5634	5628	6431	5926	6005	6366	6319	7124	7233
Energy and Water Supply	8965	10251	14981	20073	24362	26720	30037	30040	32448	23372	24098	22596	22743	24909
Manufacture	40696	45918	53241	56400	57300	61350	64073	69389	74776	80066	86559	95882	103426	109550
Construction	8076	9315	11114	12882	13539	14614	16322	17664	18731	21229	25215	30693	34617	37259
Distribution	28862	33022	38527	42458	45453	48954	53362	58062	63169	69756	76523	85436	96740	106114
Services	43735	49816	58625	72024	78202	84696	96099	102699	114534	128264	144354	161409	179456	152901
Total	133845	151854	180453	208426	224003	241968	265521	284285	309584	328692	363115	402335	444106	437966
Raw Profit (£M)														
Agriculture, Forestry and Fishing	2578	2516	2799	3137	3583	3943	3800	4542	3903	3977	4323	4167	4854	4766
Energy and Water Supply	5320	5926	9788	13505	17073	19012	22344	23976	24662	15350	17061	14536	14100	15545
Manufacture	11715	12742	14553	13185	12776	15245	16989	19389	21313	23661	26856	31964	33853	32916
Construction	3123	3652	4523	5247	5703	6509	7647	8532	9300	11281	14306	18238	20255	21063
Distribution	10927	12503	13929	13620	13782	15536	17514	19256	21932	25810	29312	33611	36468	38010
Services	13610	15672	18891	20156	21331	22915	27393	27452	32780	36847	42646	46527	50991	48426
Total	47273	53011	64483	68850	74248	83160	95687	103147	113890	116926	134504	149043	160521	160726
Self-employed Wages (£M)														
Agriculture, Forestry and Fishing	606	653	779	973	1077	1181	1422	1529	1629	1685	1717	1842	2016	2194
Energy and Water Supply	0	0	0	9	10	11	12	10	13	15	14	33	37	41
Manufacture	580	661	757	916	1066	1180	1298	1694	2077	2280	2877	3190	3786	4240
Construction	1135	1724	1825	2303	2691	3038	3468	4160	4419	4993	5950	7154	9694	9064
Distribution	2379	2049	2363	3723	4510	4845	5317	6465	6692	7149	8262	8755	9926	10988
Services	2052	2467	2699	3153	3300	3743	4675	5559	6826	7452	8872	10328	11157	8904
Total	6753	7554	8423	11078	12654	13998	16192	19417	21655	23573	27693	31301	36617	35431
Adjusted Profits (£M)														
Agriculture, Forestry and Fishing	1972	1863	2020	2164	2506	2762	2378	3013	2274	2292	2606	2325	2838	2572
Energy and Water Supply	5320	5926	9788	13496	17063	19001	22332	23966	24649	15335	17047	14503	14063	15504
Manufacture	11135	12081	13796	12269	11710	14065	15691	17695	19236	21381	23979	28774	30067	28676
Construction	1988	1928	2698	2944	3012	3471	4179	4372	4881	6288	8356	11084	10561	11999
Distribution	8548	10454	11566	9897	9272	10691	12197	12791	15240	18661	21050	24856	26542	27022
Services	11558	13205	16192	17003	18031	19172	22718	21893	25954	29395	33774	36199	39834	39522
Total	40520	45457	56060	57772	61594	69162	79495	83730	92235	93353	106811	117742	123904	125295

Table A3.2: Profits for U.K.

APPENDIX NO 4:
CALCULATION OF RETURNS

Experience is the name everyone gives to their mistakes

Oscar Wilde

A4.1: Return on capital invested

A4.1.1: Direct return on capital invested

Table:

Table A4.1/90D: Calculation of direct return on capital invested 1990

Notes:

The above table is an example of the sheets used for the computation of direct return on capital invested. Limitation of space forbids the inclusion of the other 42 tables. The first step involves taking the appropriate capital matrix from Table A2.4.2 above and also the capital depreciation vector from Table A2.1A-C. The appropriate adjusted profit vector is then taken from Table A3.1A-C.

The [6 x 11] capital matrix is then tranposed to give an [11 x 6] matrix. The column totals are then placed on the leading diagonal of the diagonalized Direct Capital Matrix which is then inverted. If post-multiplied by the capital matrix, this will give the total factor quota matrix. This is used to identify the composite depreciation rate *via* equation (6.21).

The direct profit margin is obtained by dividing adjusted profit for each industry by the total capital usage for each industry. The direct discount rate is obtained by deducting the composite depreciation rate from the direct profit margin.

A4.1.2: Total return on capital invested

Table:

Table A4.1/90T: Calculation of total return on capital invested 1990

Notes:

The above sample computation sheet is presented to illustrate the mode of calculation.

This is computed as above except that the appropriate (supply-side) Leontief inverse is required. This is used to synthesize both inputs and outputs in calculating both the composite depreciation rate and the total returns and total discount rate.

A4.1.3: Total return on capital invested in Eigenprices

Table A4.1/85D: Calculation of Direct Return on Capital Invested for 1985							
Direct Capital Usage			K				
	Agriculture	Energy	Manufacture	Construction	Distribution	Services	All Industries
Real Estate	17724	70493	59160	2454	62936	197200	409967
Dwellings	0	0	0	0	0	390065	390065
Road Vehicles	761	433	3660	1378	9994	7172	23398
Railway Rolling Stock	0	0	0	0	961	0	961
Ships	0	0	0	0	7629	0	7629
Aircraft	0	0	0	0	3345	0	3345
Metal Goods	1258	22340	28298	603	13409	12245	78153
Plant	2548	2133	3184	1103	1179	2819	12967
Mechanical Engineering	182	4367	37597	929	4152	7804	55031
Electrical Engineering	148	19100	11767	259	30657	21788	83719
Working Capital	3686	5802	41776	6502	29559	2471	89796
Total	26307	124667	185443	13230	163822	641564	1155032
Diagonalized Direct Capital Matrix Inverse							
	Agriculture	Energy	Manufacture	Construction	Distribution	Services	
Agriculture, Forestry and Fishing	3.80133E-05	0	0	0	0	0	
Energy and Water Supply	0	8.02135E-06	0	0	0	0	
Manufacture	0	0	5.39251E-06	0	0	0	
Construction	0	0	0	7.55867E-05	0	0	
Distribution, Transportation, and Communication	0	0	0	0	6.10419E-06	0	
Services	0	0	0	0	0	1.55869E-06	

Table A4.1/85D: Calculation of Direct Return on Capital Invested for 1985

Table A4.1/85D: Calculation of Direct Return on Capital Invested for 1985 (Cont)

Total Capital Quota Matrix

	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Depreciation Vector
Real Estate	0.67373	0.56545	0.31902	0.18552	0.38417	0.30737	2%
Dwellings	0	0	0	0	0	0.60799	1%
Road Vehicles	0.02891	0.00347	0.01974	0.10419	0.06101	0.01118	20%
Railway Rolling Stock	0	0	0	0	0.00587	0	15%
Ships	0	0	0	0	0.04657	0	10%
Aircraft	0	0	0	0	0.02042	0	15%
Metal Goods	0.04783	0.17920	0.15260	0.04558	0.08185	0.01909	5%
Plant	0.09686	0.01711	0.01717	0.08340	0.00720	0.00439	20%
Mechanical Engineering	0.00693	0.03503	0.20274	0.07025	0.02534	0.01216	8%
Electrical Engineering	0.00562	0.15321	0.06346	0.01959	0.18714	0.03396	5%
Working Capital	0.14012	0.04654	0.22528	0.49146	0.18043	0.00385	0%
Total	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	

Results

	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Composite Depreciation	4.19%	3.48%	4.08%	5.01%	4.54%	1.90%
Direct Profit	2292	15335	21381	6288	18661	29395
Direct Capital Usage	26307	124667	185443	13230	163822	641564
Direct Return	8.71%	12.30%	11.53%	47.53%	11.39%	4.58%
Direct Discount Rate	4.53%	8.82%	7.45%	42.52%	6.85%	2.68%

Table A4.1/85D: Calculation of Direct Return on Capital Invested for 1985

Table A4.1/85/T: Total Return on Capital Invested for 1985							
Supply-side Leontief Inverse			[I - B] inverse				
	Agriculture	Energy	Manufacture	Construction	Distribution	Services	
Agriculture, Forestry and Fishing	1.2313	0.0263	0.9331	0.0542	0.1026	0.0379	
Energy and Water Supply	0.0294	1.3267	0.2553	0.0367	0.1446	0.0541	
Manufacture	0.0383	0.0383	1.4045	0.0798	0.1088	0.0478	
Construction	0.0053	0.0032	0.0293	1.2733	0.0307	0.0510	
Distribution, Transportation, and Communication	0.0114	0.0326	0.2081	0.0286	1.1211	0.0772	
Services	0.0196	0.0417	0.1998	0.0549	0.1165	1.1112	
Direct Capital Usage			K				
	Agriculture	Energy	Manufacture	Construction	Distribution	Services	All Industries
Real Estate	17724	70493	59160	2454	62936	197200	409967
Dwellings	0	0	0	0	0	390065	390065
Road Vehicles	761	433	3660	1378	9994	7172	23398
Railway Rolling Stock	0	0	0	0	961	0	961
Ships	0	0	0	0	7629	0	7629
Aircraft	0	0	0	0	3345	0	3345
Metal Goods	1258	22340	28298	603	13409	12245	78153
Plant	2548	2133	3184	1103	1179	2819	12967
Mechanical Engineering	182	4367	37597	929	4152	7804	55031
Electrical Engineering	148	19100	11767	259	30657	21788	83719
Working Capital	3686	5802	41776	6502	29559	2471	89796
Total	26307	124667	185443	13230	163822	641564	1155032

Table A4.1/85T: Calculation of Total Return on Capital Invested

Table A4.1/85/T: Total Return on Capital Invested for 1985 (Cont)							
Total Capital Usage			K [I - B] inverse				
	Agriculture	Energy	Manufacture	Construction	Distribution	Services	All Industries
Real Estate	30760	106527	170202	24019	112057	231428	674994
Dwellings	7650	16257	77946	21421	45447	433440	602161
Road Vehicles	1351	1363	9515	2784	12621	9039	36673
Railway Rolling Stock	11	31	200	27	1078	74	1422
Ships	87	248	1588	218	8553	589	11284
Aircraft	38	109	696	96	3750	258	4947
Metal Goods	3686	31703	51877	4968	22916	17283	132432
Plant	3397	3178	8235	2064	2601	3645	23119
Mechanical Engineering	1997	7701	56539	4899	10332	11081	92549
Electrical Engineering	1972	27700	32284	4051	40974	28193	135174
Working Capital	6727	10480	70430	13004	39387	7812	147841
Total	57677	205298	479512	77551	299716	742842	1862595
Diagonalized Total Capital Matrix Inverse							
Agriculture, Forestry and Fishing	1.73381E-05	0	0	0	0	0	
Energy and Water Supply	0	4.87098E-06	0	0	0	0	
Manufacture	0	0	2.08545E-06	0	0	0	
Construction	0	0	0	1.28947E-05	0	0	
Distribution, Transportation, and Communication	0	0	0	0	3.33649E-06	0	
Services	0	0	0	0	0	1.34618E-06	

Table A4.1/85T: Calculation of Total Return on Capital Invested

Table A4.1/85/T: Total Return on Capital Invested for 1985 (Cont)

Total Capital Quota Matrix	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Depreciation Vector
Real Estate	0.53332	0.51889	0.35495	0.30972	0.37388	0.31154	2%
Dwellings	0.13264	0.07919	0.16255	0.27621	0.15163	0.58349	1%
Road Vehicles	0.02343	0.00664	0.01984	0.03590	0.04211	0.01217	20%
Railway Rolling Stock	0.00019	0.00015	0.00042	0.00035	0.00360	0.00010	15%
Ships	0.00151	0.00121	0.00331	0.00281	0.02854	0.00079	10%
Aircraft	0.00066	0.00053	0.00145	0.00123	0.01251	0.00035	15%
Metal Goods	0.06391	0.15442	0.10819	0.06407	0.07646	0.02327	5%
Plant	0.05889	0.01548	0.01717	0.02661	0.00868	0.00491	20%
Mechanical Engineering	0.03462	0.03751	0.11791	0.06318	0.03447	0.01492	8%
Electrical Engineering	0.03419	0.13493	0.06733	0.05223	0.13671	0.03795	5%
Working Capital	0.11664	0.05105	0.14688	0.16769	0.13142	0.01052	0%
Total	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	

Results	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Composite Depreciation	3.64%	3.33%	3.49%	3.28%	3.78%	1.99%
Direct Profit	2292	15335	21381	6288	18661	29395
Total Profit	4914	23076	46026	12547	29318	36364
Total Capital Usage	57677	205298	479512	77551	299716	742842
Total Return	8.52%	11.24%	9.60%	16.18%	9.78%	4.90%
Total Discount Rate	4.88%	7.91%	6.10%	12.89%	6.00%	2.91%

Table A4.1/85T: Calculation of Total Return on Capital Invested

Table A4.1/85E: Calculation of Total Return on Capital Invested in Eigenprices for 1985							
Supply-side Leontief Inverse			[I - B] inverse				
	Agriculture	Energy	Manufacture	Construction	Distribution	Services	
Agriculture, Forestry and Fishing	1.23132	0.02633	0.93308	0.05419	0.10258	0.03790	
Energy and Water Supply	0.02945	1.32667	0.25533	0.03669	0.14464	0.05410	
Manufacture	0.03826	0.03828	1.40446	0.07976	0.10876	0.04784	
Construction	0.00531	0.00324	0.02930	1.27325	0.03072	0.05099	
Distribution, Transportation, and Communication	0.01138	0.03255	0.20815	0.02860	1.12110	0.07721	
Services	0.01961	0.04168	0.19983	0.05492	0.11651	1.11120	
Direct Capital Usage			K				
	Agriculture	Energy	Manufacture	Construction	Distribution	Services	All Industries
Real Estate	17724	70493	59160	2454	62936	197200	409967
Dwellings	0	0	0	0	0	390065	390065
Road Vehicles	761	433	3660	1378	9994	7172	23398
Railway Rolling Stock	0	0	0	0	961	0	961
Ships	0	0	0	0	7629	0	7629
Aircraft	0	0	0	0	3345	0	3345
Metal Goods	1258	22340	28298	603	13409	12245	78153
Plant	2548	2133	3184	1103	1179	2819	12967
Mechanical Engineering	182	4367	37597	929	4152	7804	55031
Electrical Engineering	148	19100	11767	259	30657	21788	83719
Working Capital	3686	5802	41776	6502	29559	2471	89796
Total	26307	124667	185443	13230	163822	641564	1155032
	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Capital
Eigenprices	1.0576	1.0342	0.9992	0.9996	0.9818	1.0013	1.0029

Table 4.1/85E: Calculation of Total Return on Capital Invested in Eigenprices for 1985

Table A4.1/85E: Calculation of Total Return on Capital Invested in Eigenprices for 1985 (Cont)

Capital Matrix Scaled into Eigenprices

	Agriculture	Energy	Manufacture	Construction	Distribution	Services	All Industries
Real Estate	17716	70462	59134	2453	62908	197113	409786
Dwellings	0	0	0	0	0	389893	389893
Road Vehicles	760	432	3657	1377	9987	7167	23380
Railway Rolling Stock	0	0	0	0	961	0	961
Ships	0	0	0	0	7624	0	7624
Aircraft	0	0	0	0	3342	0	3342
Metal Goods	1257	22323	28277	603	13399	12235	78093
Plant	2546	2132	3181	1103	1178	2817	12957
Mechanical Engineering	182	4364	37568	929	4148	7798	54989
Electrical Engineering	148	19085	11758	259	30634	21772	83655
Working Capital	3898	6001	41744	6499	29021	2474	89637
Total	26507	124798	185320	13223	163201	641269	1154318

Total Capital Usage

	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Real Estate	30746	106480	170127	24009	112008	231326
Dwellings	7647	16250	77912	21411	45427	433249
Road Vehicles	1350	1362	9507	2782	12612	9032
Railway Rolling Stock	11	31	200	27	1077	74
Ships	87	248	1587	218	8547	589
Aircraft	38	109	696	96	3747	258
Metal Goods	3683	31678	51837	4965	22898	17269
Plant	3394	3176	8229	2062	2599	3642
Mechanical Engineering	1995	7695	56496	4896	10324	11073
Electrical Engineering	1971	27679	32259	4047	40942	28172
Working Capital	6987	10730	70523	13002	38831	7791
Total	57910	205439	479372	77514	299012	742474

Table 4.1/85E: Calculation of Total Return on Capital Invested in Eigenprices for 1985

Table A4.1/85E: Calculation of Total Return on Capital Invested in Eigenprices for 1985 (Cont)

Diagonalized Total Capital Matrix Inverse

	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Agriculture, Forestry and Fishing	1.72682E-05	0	0	0	0	0
Energy and Water Supply	0	4.86763E-06	0	0	0	0
Manufacture	0	0	2.08606E-06	0	0	0
Construction	0	0	0	1.29009E-05	0	0
Distribution, Transportation, and Communication	0	0	0	0	3.34435E-06	0
Services	0	0	0	0	0	1.34685E-06

Total Capital Quota Matrix

	Agriculture	Energy	Manufacture	Construction	Distribution	Services	Depreciation Vector
Real Estate	0.53093	0.51831	0.35490	0.30973	0.37459	0.31156	2%
Dwellings	0.13205	0.07910	0.16253	0.27623	0.15192	0.58352	1%
Road Vehicles	0.02331	0.00663	0.01983	0.03589	0.04218	0.01216	20%
Railway Rolling Stock	0.00019	0.00015	0.00042	0.00035	0.00360	0.00010	15%
Ships	0.00150	0.00121	0.00331	0.00281	0.02858	0.00079	10%
Aircraft	0.00066	0.00053	0.00145	0.00123	0.01253	0.00035	15%
Metal Goods	0.06360	0.15420	0.10814	0.06405	0.07658	0.02326	5%
Plant	0.05861	0.01546	0.01717	0.02660	0.00869	0.00490	20%
Mechanical Engineering	0.03446	0.03746	0.11785	0.06316	0.03453	0.01491	8%
Electrical Engineering	0.03403	0.13473	0.06729	0.05222	0.13693	0.03794	5%
Working Capital	0.12066	0.05223	0.14711	0.16773	0.12987	0.01049	0%
Total	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	

Table 4.1/85E: Calculation of Total Return on Capital Invested in Eigenprices for 1985

Table A4.1/85E: Calculation of Total Return on Capital Invested in Eigenprices for 1985 (Cont)

Return	Agriculture	Energy	Manufacture	Construction	Distribution	Services
Composite Depreciation	3.62%	3.32%	3.49%	3.28%	3.79%	1.99%
Direct Profit	2292	15335	21381	6288	18661	29395
Total Profit	4914	23076	46026	12547	29318	36364
Scaled Total Profit	4928	23143	46158	12583	29402	36468
Scaled Capital Usage	57910	205439	479372	77514	299012	742474
Total Return	8.51%	11.26%	9.63%	16.23%	9.83%	4.91%
Total Discount Rate	4.89%	7.94%	6.14%	12.95%	6.04%	2.92%

Table 4.1/85E: Calculation of Total Return on Capital Invested in Eigenprices for 1985

Table:

Table A4.1/90E: Calculation of total return on capital invested in Eigenprices 1990

Notes:

The above is again included as an illustration of the method of computation.

It follows the same pattern as Table A4.1/90T except that both the capital inputs and the profit outputs are scaled by the appropriate eigenprice as outlined in equations (6.10) to (6.13) and (6.16). The supply-side Leontief is not affected by the scaling process and is taken as above.

A4.2: Results

Table:

Table A4.2A: Results 1948-61
Table A4.2B: Results 1962-76
Table A4.2C: Results 1977-90

Charts:

Chart A4.2.1A: Direct return on capital invested 1948-61
Chart A4.2.1B: Direct return on capital invested 1962-76
Chart A4.2.1B: Direct return on capital invested 1977-90
Chart A4.2.2A: Total return on capital invested 1948-61
Chart A4.2.2B: Total return on capital invested 1962-76
Chart A4.2.2B: Total return on capital invested 1977-90
Chart A4.2.3A: Eigenprice return on capital invested 1948-61
Chart A4.2.3B: Eigenprice return on capital invested 1962-76
Chart A4.2.3B: Eigenprice return on capital invested 1977-90

Notes:

The above tables and charts summarizes the returns obtained using the three approaches presented in both tabular and graphical representation.

Table A4.2A: Results 1947-1961															
	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
Direct Return on Capital Invested (%)															
Agriculture, Forestry and Fishing	-	12.00%	12.82%	11.81%	11.89%	12.16%	11.72%	10.51%	9.92%	9.08%	8.73%	7.51%	7.25%	7.62%	9.56%
Energy and Water Supply	-	2.34%	2.48%	2.73%	1.87%	1.48%	2.17%	2.26%	1.67%	2.52%	1.96%	2.26%	2.49%	2.88%	3.04%
Manufacture	-	17.02%	16.11%	17.99%	18.03%	12.38%	12.90%	14.33%	13.93%	12.35%	12.10%	10.97%	12.01%	12.37%	10.51%
Construction	-	16.71%	17.54%	15.47%	14.43%	12.54%	15.30%	14.00%	13.78%	13.43%	11.90%	11.74%	13.73%	15.81%	16.64%
Distribution, Transportation, and Communication	-	10.54%	10.33%	11.15%	12.60%	9.00%	8.60%	9.16%	9.78%	8.93%	7.88%	6.03%	6.52%	8.27%	7.32%
Services	-	3.68%	3.21%	3.47%	2.74%	2.16%	2.53%	3.22%	3.08%	2.89%	2.91%	3.37%	4.05%	4.34%	4.30%
Input-output Return on Capital Invested (%)															
Agriculture, Forestry and Fishing	-	11.26%	11.76%	10.90%	10.85%	10.52%	10.34%	9.86%	9.43%	8.62%	8.27%	7.25%	7.35%	7.88%	8.86%
Energy and Water Supply	-	3.55%	3.59%	4.05%	3.31%	2.53%	3.11%	3.29%	2.75%	3.33%	2.77%	2.90%	3.18%	3.65%	3.66%
Manufacture	-	13.16%	12.69%	12.76%	12.70%	9.68%	10.05%	11.04%	10.79%	9.73%	9.39%	8.50%	9.29%	10.03%	8.79%
Construction	-	13.06%	13.20%	11.34%	10.78%	9.44%	10.54%	10.76%	10.56%	9.88%	9.17%	8.66%	9.78%	10.98%	10.47%
Distribution, Transportation, and Communication	-	10.41%	10.20%	10.91%	12.08%	8.68%	8.41%	8.98%	9.42%	8.64%	7.68%	6.06%	6.57%	7.96%	7.10%
Services	-	3.85%	3.39%	3.70%	2.97%	2.41%	2.79%	3.49%	3.34%	3.14%	3.14%	3.54%	4.22%	4.62%	4.52%
Input-output Return on Capital Invested (%) scaled into Eigenprices															
Agriculture, Forestry and Fishing	-	10.98%	11.47%	10.62%	10.57%	10.16%	9.99%	9.52%	9.11%	8.34%	7.96%	6.99%	7.07%	7.61%	8.55%
Energy and Water Supply	-	3.62%	3.67%	4.07%	3.33%	2.60%	3.19%	3.37%	2.83%	3.42%	2.85%	2.98%	3.26%	3.73%	3.74%
Manufacture	-	13.19%	12.73%	12.68%	12.62%	9.74%	10.12%	11.11%	10.86%	9.80%	9.47%	8.58%	9.36%	10.15%	8.89%
Construction	-	12.97%	13.12%	11.17%	10.63%	9.45%	10.54%	10.77%	10.58%	9.90%	9.20%	8.69%	9.81%	11.13%	10.62%
Distribution, Transportation, and Communication	-	10.51%	10.31%	10.92%	12.07%	8.82%	8.55%	9.13%	9.57%	8.79%	7.83%	6.20%	6.71%	8.10%	7.22%
Services	-	3.72%	3.28%	3.56%	2.86%	2.36%	2.74%	3.42%	3.27%	3.07%	3.07%	3.47%	4.14%	4.70%	4.60%

Table A4.2: Results.

Table A4.2B:Results 1962-1976															
	1962	1963	1964	1965	1966	1967	1668	1969	1970	1971	1972	1973	1974	1975	1976
Direct Return on Capital Invested (%)															
Agriculture, Forestry and Fishing	8.97%	7.74%	7.41%	7.86%	8.08%	8.43%	8.12%	9.36%	9.37%	9.02%	10.86%	12.71%	11.41%	13.28%	10.70%
Energy and Water Supply	3.56%	3.89%	3.74%	3.21%	2.58%	2.55%	3.32%	3.07%	2.45%	2.67%	3.45%	3.85%	5.65%	7.48%	5.38%
Manufacture	9.29%	10.23%	10.93%	10.64%	9.34%	8.78%	9.56%	8.23%	7.82%	8.28%	9.02%	10.37%	8.74%	8.99%	6.97%
Construction	16.62%	19.36%	21.93%	19.02%	20.24%	16.15%	18.86%	18.74%	18.79%	22.36%	34.33%	36.85%	27.09%	28.81%	24.89%
Distribution, Transportation, and Communication	7.31%	7.94%	8.82%	9.43%	8.82%	8.25%	8.43%	7.30%	5.64%	6.77%	8.96%	9.60%	8.94%	7.64%	5.76%
Services	4.14%	4.22%	3.73%	3.49%	3.31%	3.81%	5.92%	5.85%	5.95%	3.80%	3.42%	3.25%	3.64%	3.50%	2.72%
Input-output Return on Capital Invested (%)															
Agriculture, Forestry and Fishing	8.28%	7.65%	7.53%	7.77%	7.73%	7.87%	7.97%	8.51%	8.36%	8.05%	9.55%	10.92%	9.70%	10.85%	8.64%
Energy and Water Supply	4.03%	4.37%	4.28%	3.79%	3.21%	3.14%	3.95%	3.62%	3.09%	3.17%	3.97%	4.45%	5.75%	7.18%	5.24%
Manufacture	7.95%	8.60%	9.02%	8.80%	7.79%	7.43%	8.30%	7.38%	6.94%	6.94%	7.73%	8.56%	7.64%	7.88%	6.09%
Construction	9.93%	11.19%	12.37%	11.58%	11.04%	9.71%	11.19%	10.49%	10.35%	10.93%	15.25%	16.39%	13.60%	13.68%	11.10%
Distribution, Transportation, and Communication	7.00%	7.55%	8.22%	8.60%	8.16%	7.67%	8.05%	7.02%	5.64%	6.43%	8.35%	8.88%	7.81%	7.05%	5.35%
Services	4.33%	4.44%	4.01%	3.77%	3.55%	4.00%	6.02%	5.91%	5.97%	3.96%	3.71%	3.59%	3.85%	3.72%	2.89%
Input-output Return on Capital Invested (%) scaled into Eigenprices															
Agriculture, Forestry and Fishing	7.99%	7.39%	7.28%	7.52%	7.53%	7.66%	7.76%	8.33%	8.23%	7.89%	9.45%	10.83%	9.58%	10.73%	8.54%
Energy and Water Supply	4.11%	4.46%	4.36%	3.87%	3.24%	3.17%	3.99%	3.67%	3.12%	3.20%	4.00%	4.49%	5.77%	7.20%	5.25%
Manufacture	8.05%	8.70%	9.13%	8.91%	7.85%	7.49%	8.36%	7.44%	7.00%	6.99%	7.78%	8.62%	7.66%	7.90%	6.11%
Construction	10.06%	11.34%	12.53%	11.74%	11.17%	9.82%	11.32%	10.61%	10.49%	11.05%	15.37%	16.52%	13.63%	13.72%	11.13%
Distribution, Transportation, and Communication	7.12%	7.68%	8.36%	8.75%	8.25%	7.76%	8.14%	7.11%	5.70%	6.50%	8.42%	8.96%	7.84%	7.08%	5.37%
Services	4.41%	4.52%	4.08%	3.84%	3.68%	4.14%	6.20%	6.08%	6.18%	4.08%	3.78%	3.65%	3.86%	3.73%	2.90%

Table A4.2: Results.

Table A4.2C: Results 1977-1990

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Direct Return on Capital Invested (%)														
Agriculture, Forestry and Fishing	8.72%	6.46%	6.84%	5.70%	6.43%	7.10%	5.57%	7.76%	4.53%	4.22%	4.97%	3.46%	4.29%	3.12%
Energy and Water Supply	7.14%	6.62%	10.54%	12.04%	13.68%	14.54%	16.51%	17.07%	8.82%	8.25%	8.92%	6.39%	5.21%	5.40%
Manufacture	7.54%	7.08%	6.89%	4.41%	3.45%	4.68%	5.35%	6.08%	7.45%	6.98%	7.70%	9.16%	8.62%	7.14%
Construction	24.20%	18.07%	22.13%	21.98%	21.91%	25.03%	30.41%	30.76%	42.52%	39.48%	49.23%	57.20%	47.58%	46.74%
Distribution, Transportation, and Communication	7.64%	8.31%	7.54%	4.10%	2.77%	3.40%	4.11%	3.97%	6.85%	6.11%	6.47%	7.25%	6.71%	5.83%
Services	2.91%	2.82%	2.86%	2.07%	1.81%	1.87%	2.33%	1.85%	2.68%	2.32%	2.48%	2.23%	1.99%	1.59%
Input-output Return on Capital Invested (%)														
Agriculture, Forestry and Fishing	7.62%	6.12%	6.47%	5.24%	5.52%	6.08%	5.49%	6.72%	4.88%	4.49%	5.08%	4.23%	4.42%	3.50%
Energy and Water Supply	7.04%	6.55%	9.95%	11.03%	12.41%	12.62%	14.36%	14.74%	7.91%	7.35%	7.91%	5.91%	4.89%	4.89%
Manufacture	6.71%	6.27%	6.45%	4.66%	4.18%	4.75%	5.34%	5.73%	6.10%	5.61%	6.12%	6.57%	6.07%	5.07%
Construction	11.98%	10.10%	11.64%	10.04%	9.38%	8.01%	9.45%	9.32%	12.89%	11.90%	14.34%	16.43%	13.86%	13.64%
Distribution, Transportation, and Communication	6.72%	7.03%	6.77%	4.28%	3.43%	3.90%	4.60%	4.48%	6.00%	5.37%	5.72%	6.06%	5.53%	4.81%
Services	3.10%	3.00%	3.05%	2.20%	1.93%	2.07%	2.55%	2.10%	2.91%	2.53%	2.71%	2.47%	2.20%	1.79%
Input-output Return on Capital Invested (%) scaled into Eigenprices														
Agriculture, Forestry and Fishing	7.54%	6.06%	6.43%	5.20%	5.49%	6.10%	5.52%	6.75%	4.89%	4.50%	5.09%	4.24%	4.43%	3.51%
Energy and Water Supply	7.03%	6.54%	9.95%	11.02%	12.40%	12.70%	14.45%	14.84%	7.94%	7.38%	7.95%	5.93%	4.92%	4.92%
Manufacture	6.71%	6.27%	6.45%	4.66%	4.18%	4.80%	5.40%	5.79%	6.14%	5.64%	6.15%	6.61%	6.10%	5.10%
Construction	11.98%	10.10%	11.63%	10.04%	9.38%	8.09%	9.54%	9.41%	12.95%	11.96%	14.40%	16.49%	13.92%	13.70%
Distribution, Transportation, and Communication	6.73%	7.04%	6.78%	4.28%	3.43%	3.96%	4.67%	4.54%	6.04%	5.41%	5.76%	6.10%	5.57%	4.84%
Services	3.09%	3.00%	3.04%	2.20%	1.92%	2.10%	2.59%	2.13%	2.92%	2.54%	2.72%	2.48%	2.22%	1.80%

Table A4.2: Results.

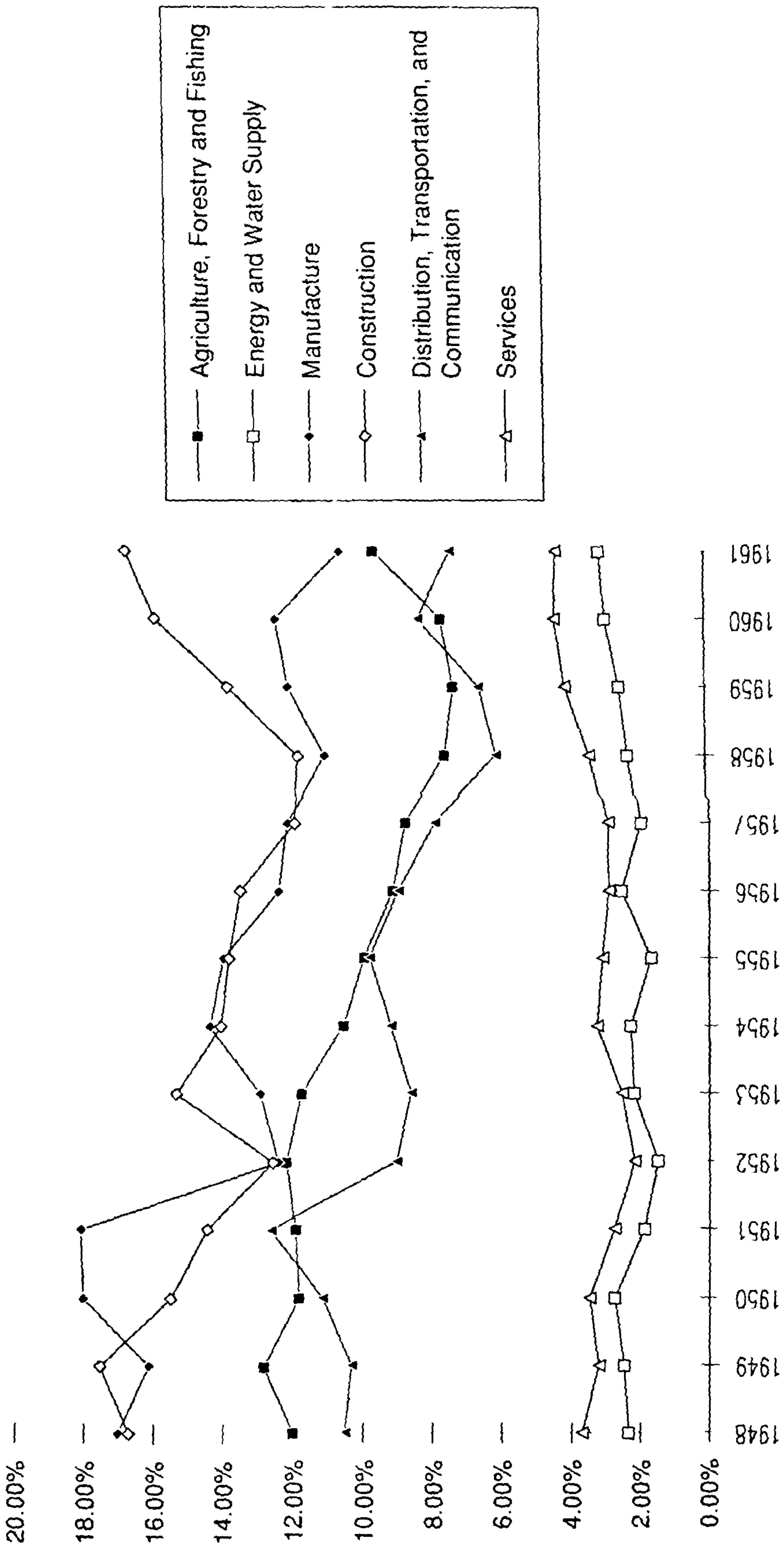

Chart A.4.2.1A; Direct return on capital invested 1948-61

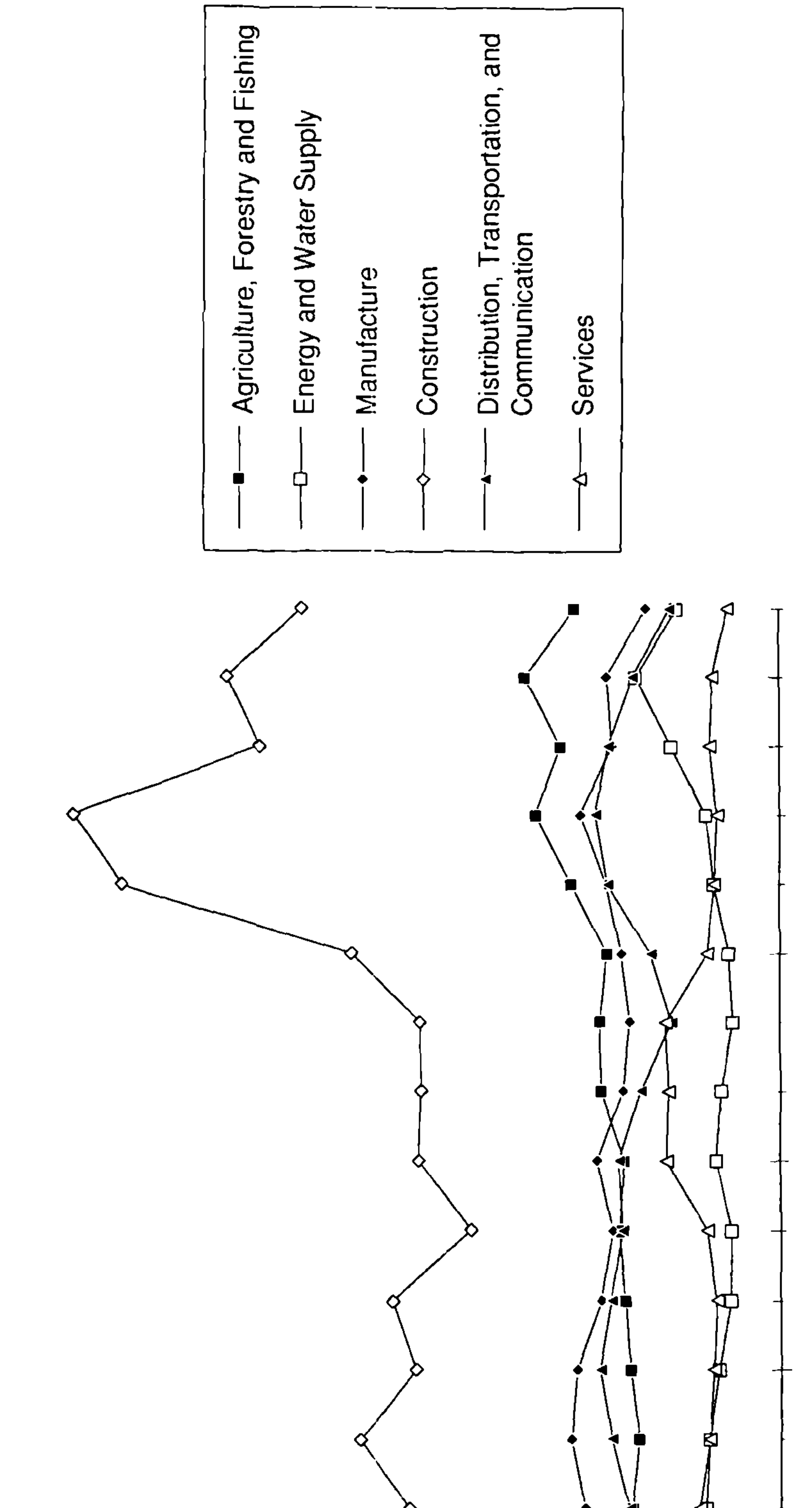

Chart 4.2.1B Direct Return on Capital Invested 1962-76

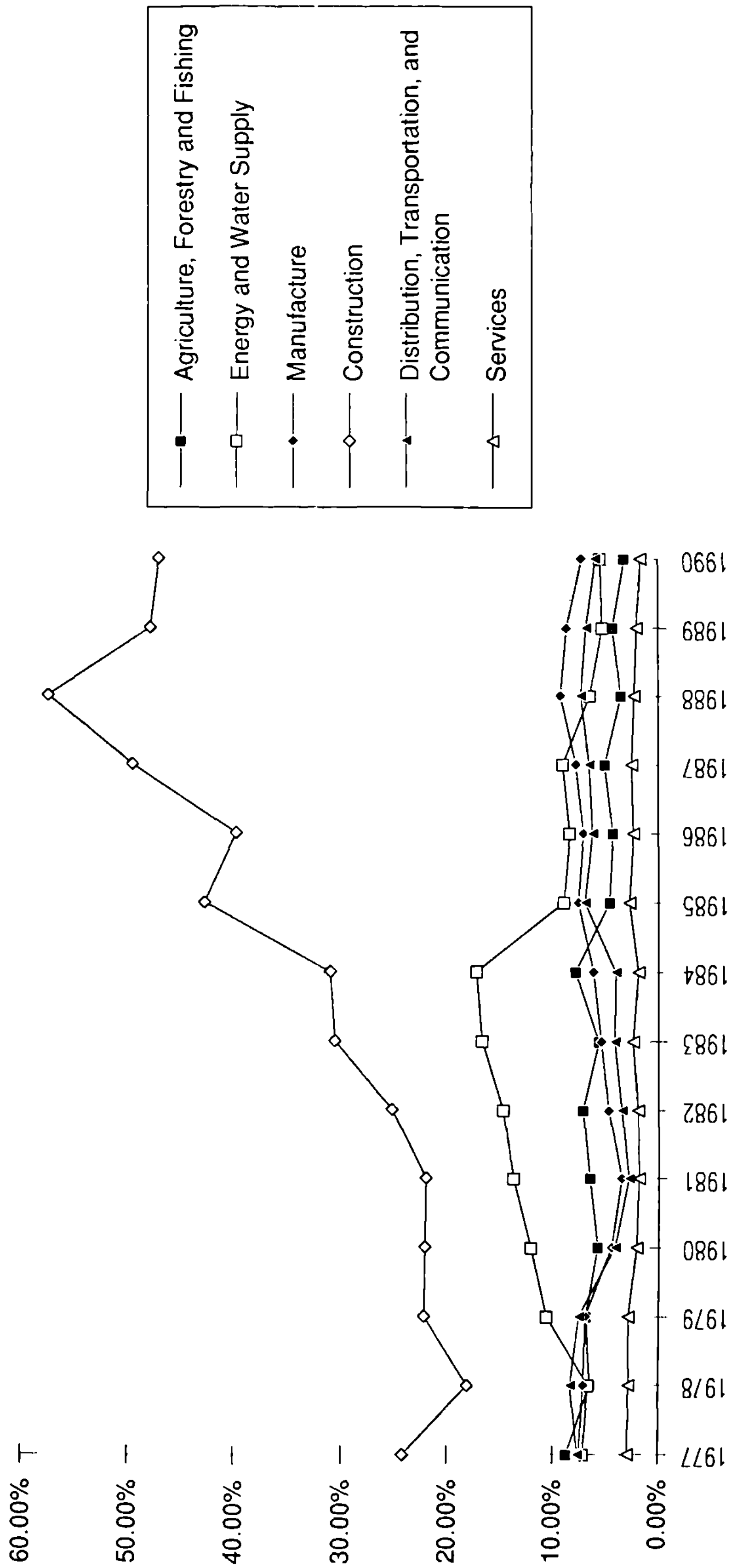

Chart A4.2.1C: Direct return on capital invested 1977-90

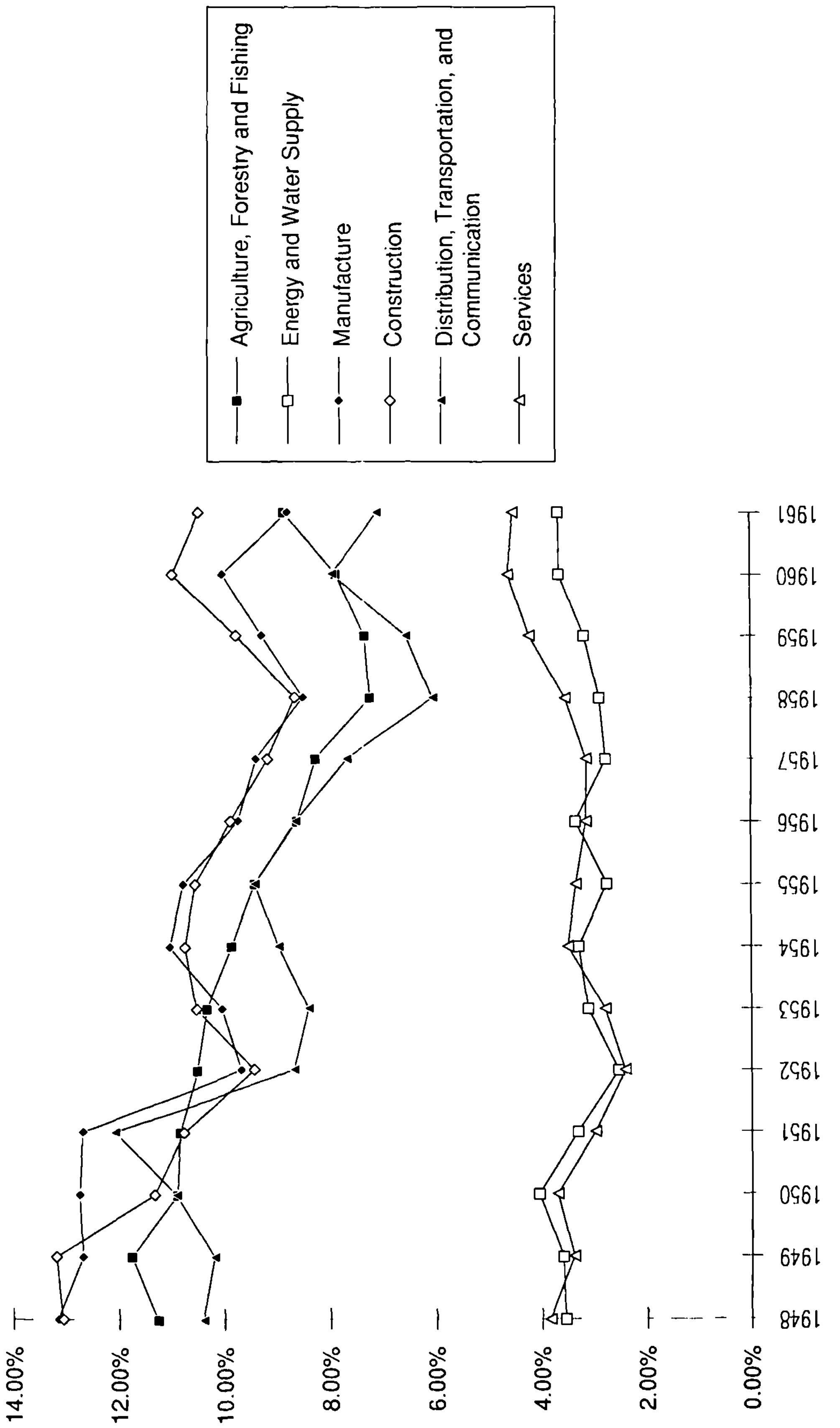

Chart A4.2.2A: Total return on capital invested 1948-61

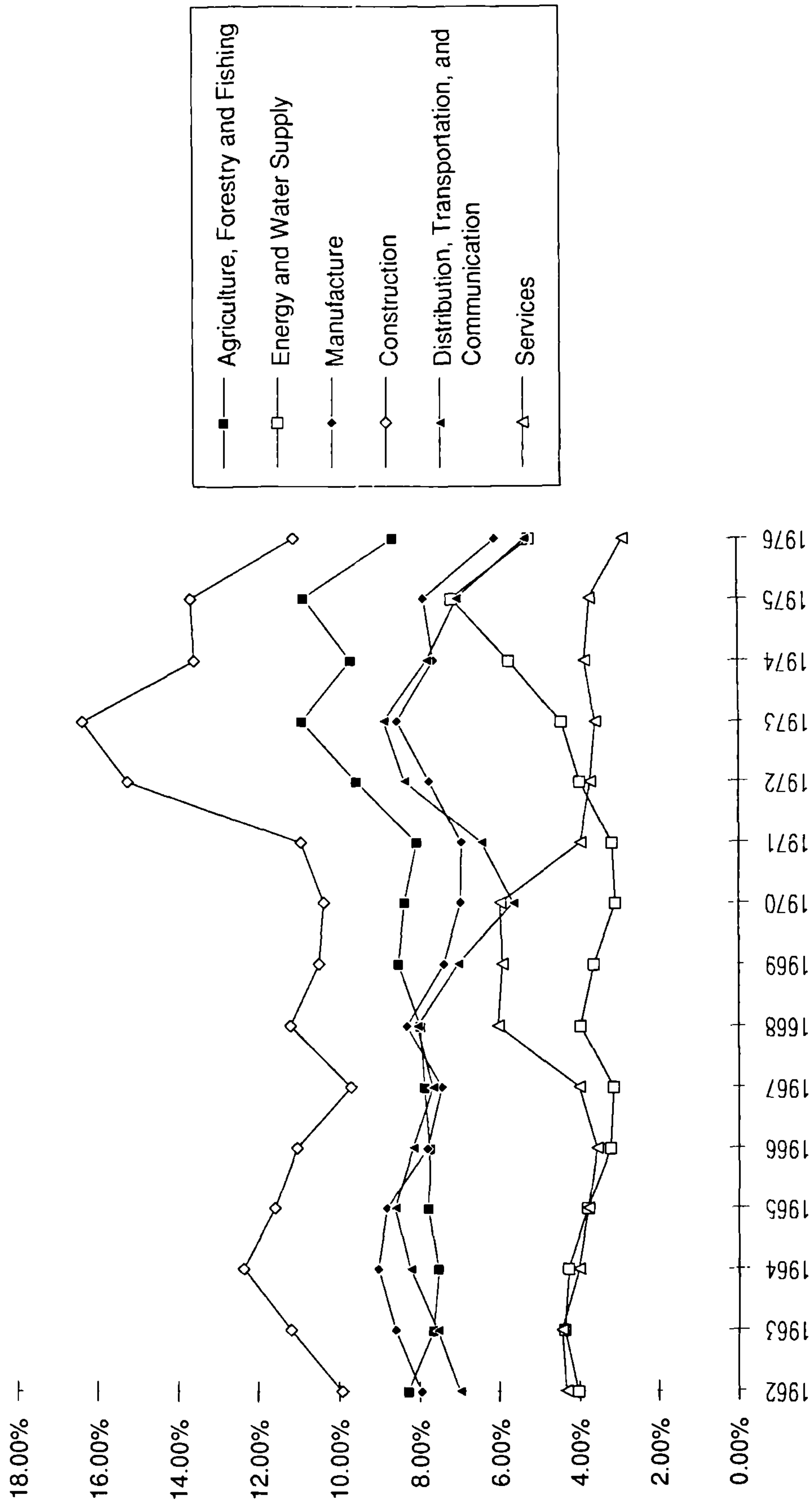

Chart A4.2.2B: Total return on capital invested 1962-76

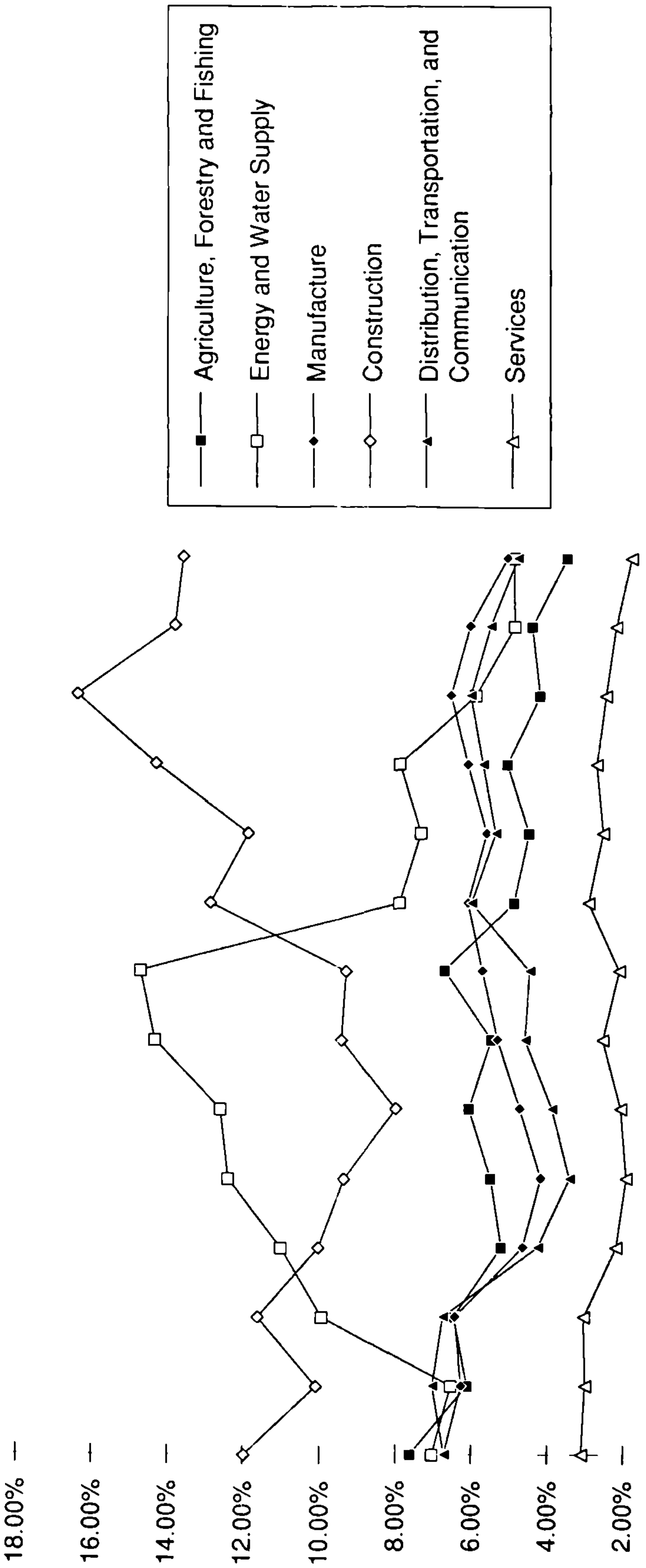

Chart A4.2.2C: Total return on capital invested 1977-90

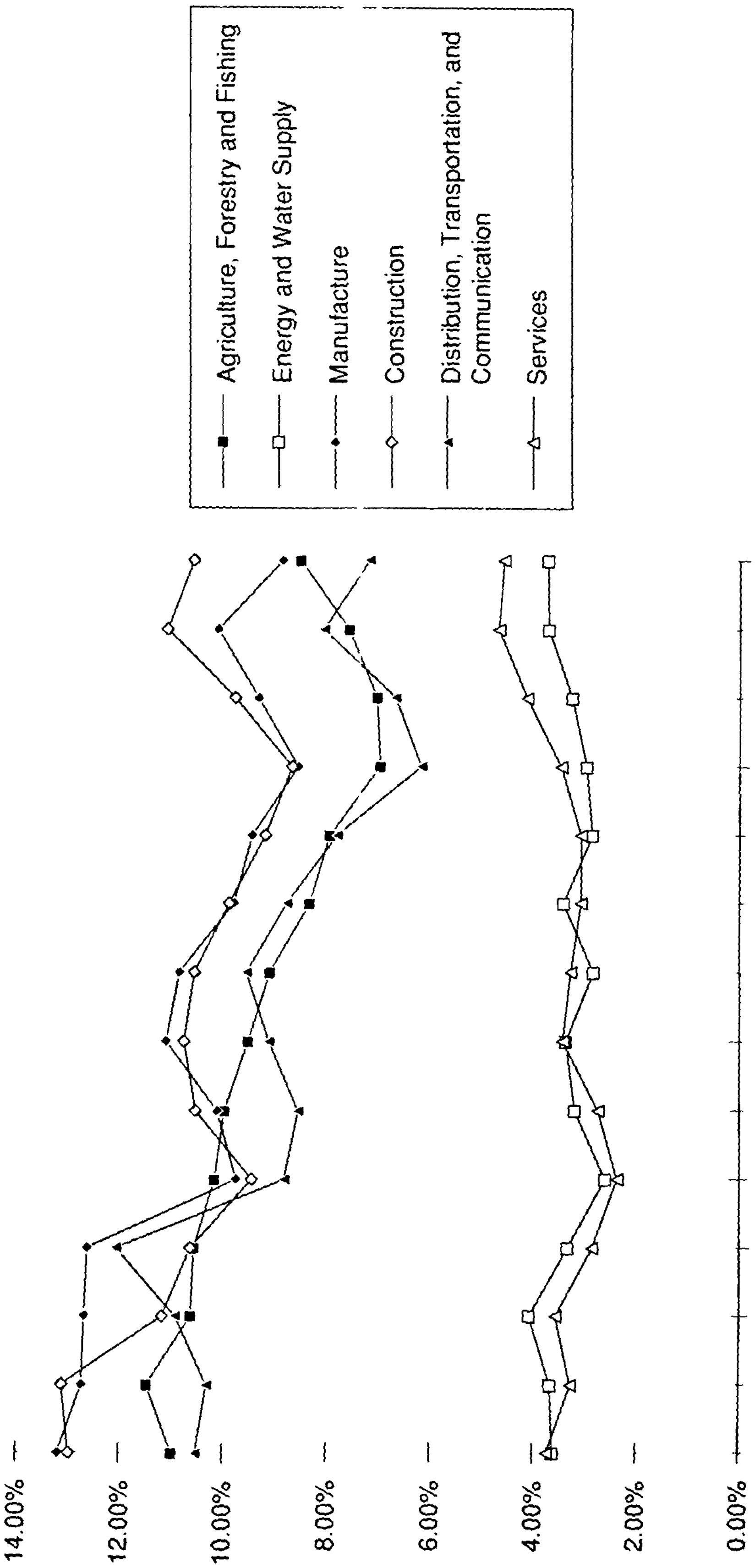

Chart A4.2.3A: Eigenprice return on capital invested 1948-61

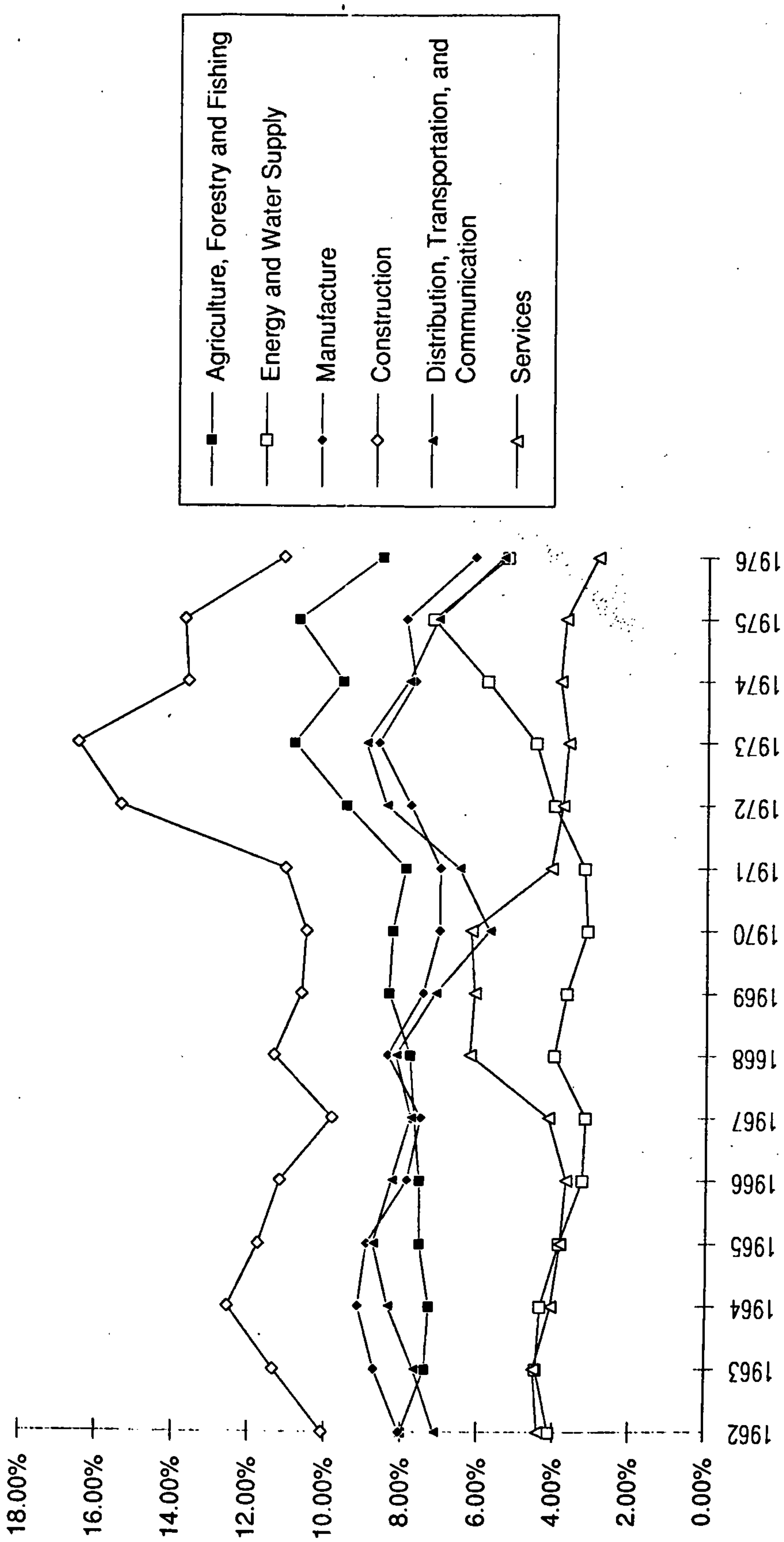

Chart A4.2.3B: Eigenprice return on capital invested 1962-76

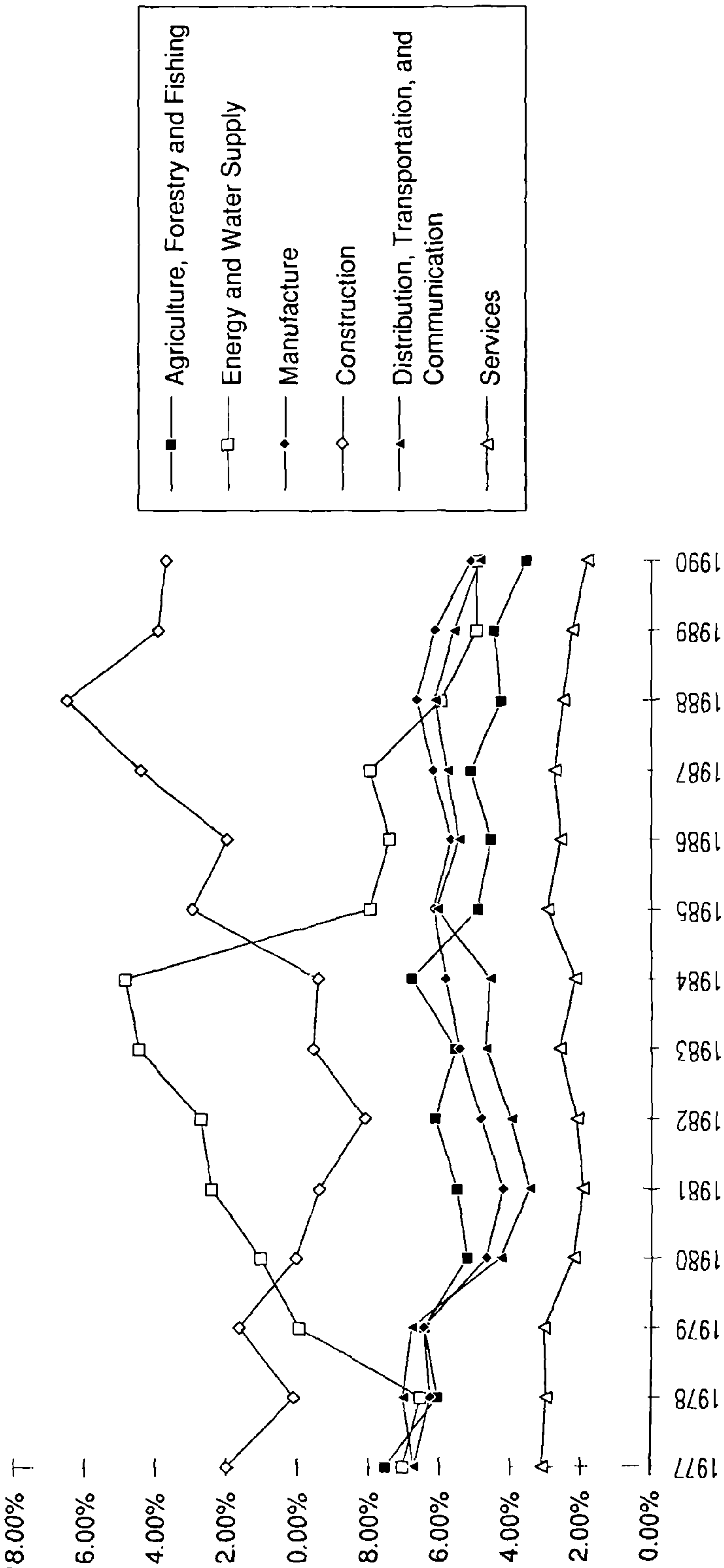

Chart A4.2.3C: Eigenprice return on capital invested 1977-90

APPENDIX NO 5:

EIGENPRICES

The actual price at which any commodity is sold is commonly called its market price. It may either be above or below or exactly the same with its natural price.

Adam Smith

A5.1: Introduction

A5.1.1: Background

This Appendix illustrates the implications of scaling the price levels into eigenprices for international comparisons. It is based on a four country analysis over a twenty to thirty year period. The countries used are Japan, Finland, and Eire in addition to the UK.

A5.1.2: Data used

The input-output tables used in the analysis ¶ were consolidated to the same level of articulation as for the UK in Appendix No 1. However the classification system for certain countries made direct comparison impossible. For example in the tables for Japan, Trade is included with Services rather than with Transportation and Communication. The differences were minor in scope and did not affect the key Construction, Manufacturing and Energy sectors or, for that matter, Agriculture. Equally the classification of the inputs factor is not appreciably affected. No figures are available for sales by final demand for the Japan, Finland, and Eire.

Five sets of tables were used for each country over the period 1960 to 1985, as follows:

UK	1963	**Finland**	1965	**Eire**	1964	**Japan**	1960
	1968		1970		1968		1965
	1974		1980		1974		1970
	1979		1982		1978		1975
	1984		1985		1982		1980

Table A5.1.1: Input output tables used in international comparison

A5.1.3: Computation

The same approach to calculating the eigenprices was used as for the UK. This is outlined in Chapter No 5 and 6 and in Appendix No 1. Table No A1.3.3/85 on pages A/1/20-24 gives an example of the spreadsheet output for this computation.

¶ The input-output data for Eire, Japan and Finland was obtained from the ECERU database at the Department of Building Engineering, University of Reading. This information was adapted and consolidated to fit into the same format as far possible to the tables for the UK used in the main analysis.

UK	1963	1968	1974	1979	1984	RMS	Mean
Agriculture	1.1608	1.1261	1.0756	1.0502	1.0631	0.2323	1.0951
Energy	0.9791	0.9961	1.0451	1.0128	1.0474	0.0700	1.0161
Manufacturing	0.9966	1.0078	0.9979	0.9998	0.9977	0.0091	1.0000
Construction	0.9908	0.9739	0.9988	1.0023	0.9980	0.0279	0.9928
Distribution	0.9857	0.9857	0.9929	0.9880	0.9814	0.0308	0.9868
Services	0.9978	0.9971	0.9935	1.0040	0.9999	0.0085	0.9985
Imports	1.0024	1.0032	1.0044	1.0003	1.0034	0.0069	1.0027
Sales	1.0002	1.0025	1.0002	0.9998	0.9974	0.0036	1.0000
Wages	0.9991	0.9991	0.9985	0.9996	0.9971	0.0035	0.9987
Profits	1.0047	1.0024	1.0010	1.0009	1.0048	0.0073	1.0027

Finland	1965	1970	1980	1982	1985	RMS	Mean
Agriculture	1.0185	1.0139	1.0190	0.9981	0.9799	0.0361	1.0059
Energy	1.0056	0.9961	0.9897	0.9764	0.9469	0.0594	0.9829
Manufacturing	1.0017	1.0155	1.0380	1.0156	0.9939	0.0443	1.0129
Construction	0.9719	0.9443	0.9417	0.9251	0.9043	0.1485	0.9375
Distribution	0.9767	0.9636	0.9776	0.9719	0.9563	0.0712	0.9692
Services	1.0199	0.9448	0.9682	0.9438	0.9238	0.1158	0.9601
Imports	1.0007	0.9785	1.0366	0.9931	0.9396	0.0742	0.9897
Wages	0.9973	0.9609	0.9844	0.9567	0.9212	0.0994	0.9641
Interest	0.9976	0.9533	0.9993	0.9350	0.8996	0.1285	0.9569

Eire	1964	1968	1974	1978	1982	RMS	Mean
Agriculture	0.9916	1.0815	1.1483	1.1149	1.1343	0.2449	1.0941
Energy	1.0311	0.9849	1.0155	1.1153	0.9902	0.1217	1.0274
Manufacturing	1.0356	1.0831	1.0946	1.0719	1.0838	0.1712	1.0738
Construction	1.0224	1.0120	0.9847	0.9868	1.0049	0.0329	1.0022
Distribution	0.9956	0.9676	0.9476	0.9812	0.9839	0.0665	0.9752
Services	0.9528	0.8807	0.8711	0.8672	0.8583	0.2661	0.8860
Imports	1.0160	1.0318	1.0395	1.0248	1.0195	0.0618	1.0263
Wages	0.9950	0.9990	0.9980	1.0002	1.0068	0.0088	0.9998
Profits	0.9995	0.9952	0.9931	0.9904	0.9934	0.0144	0.9943

Japan	1960	1965	1970	1975	1980	RMS	Mean
Agriculture	1.0378	1.0330	1.0545	1.0222	1.0287	0.0825	1.0352
Energy	0.9126	0.9343	0.9729	0.9662	0.9757	0.1201	0.9523
Manufacturing	0.9725	0.9789	0.9828	0.9822	0.9735	0.0501	0.9780
Construction	1.0112	1.0075	1.0065	1.0064	1.0044	0.0169	1.0072
Distribution	1.0350	1.0323	1.0279	1.0164	1.0244	0.0625	1.0272
Services	1.0252	1.0150	1.0093	1.0063	1.0091	0.0327	1.0130
Imports	1.0027	1.0014	1.0007	1.0003	1.0005	0.0032	1.0011
Wages	0.9989	0.9997	0.9998	1.0002	1.0002	0.0012	0.9997
Profits	0.9997	0.9983	0.9995	0.9993	0.9992	0.0020	0.9992

Table A5.1.1: International Comparison of Eigenprices

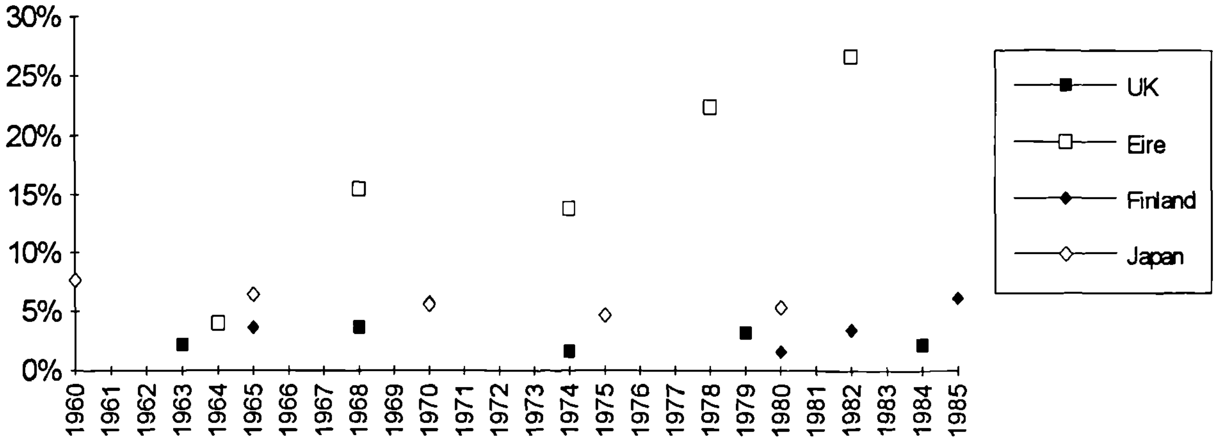

Figure A5.2.1: Eigenyields

A5.2: Results of International Analysis

A5.2.1: Figures for the four countries

The eigenprices for the UK, Finland, Eire and Japan are tabulated above in Table No A5.1.1. The figures for the UK have been discussed elsewhere. The eigen-prices are notable in that they are very near to unity except for agriculture, forestry, and fishing, and for energy and water supply. Construction and manufacturing are particularly close to unity. Finland by contrast displays a degree of variation over time and between industrial sectors. Eire starts off remarkably similar to the UK but diverges sharply in recent years with heavy subsidies to the agricultural and manufacturing sectors and high taxation on services. Finally, Japan has most figures near to unity.

A5.2.2: Changes over time

To identify the movements of eigenprices over time, Table A5.1.1 presents the mean and RMS average for each industrial sector and each factor input for all countries. The RMS average represents the root mean square of the deviations of the eigenprices from unity as represented thus:

$$RMS_i = \sqrt{\sum_{t=b}^{y} (f_{it} - 1)^2} \qquad (A5.1)$$

where f_{it} = eigenprice for industrial sector i in year t

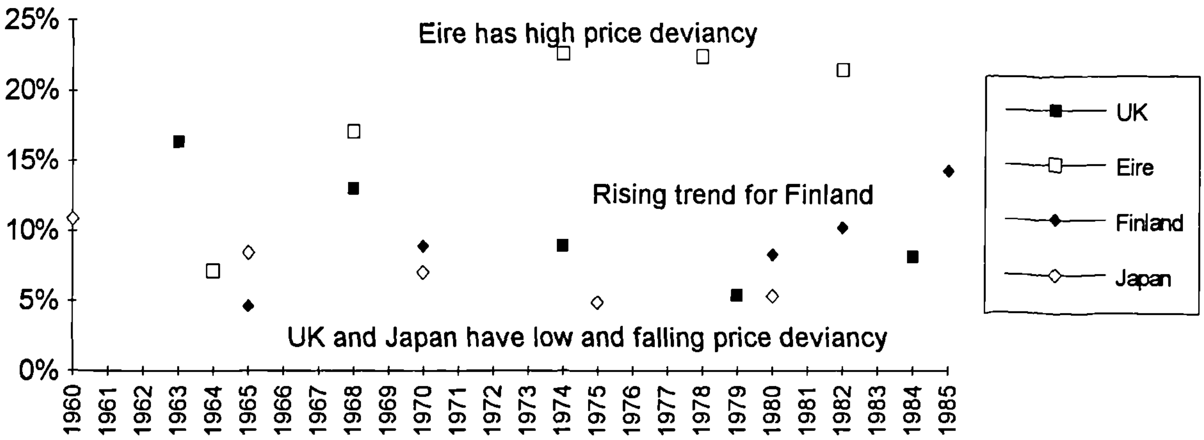

Figure A5.2.2: Eigenprice deviancy for industrial sectors

A similar approach is used to compute RMS_k using the eigenprice (n_{jt}) for each factor input for all the countries studied.

$$RMS_k \quad = \quad \sqrt{\sum_{t=b}^{y} (n_{kt} - 1)^2} \qquad (A5.2)$$

A5.2.3: Eigenyields

Table A5.2.1 above plots the eigenyields for each input-output table for all countries. This indicates generally high values for Eire and lower values for Finland and Japan, with UK generally the lowest values. This accord with the original analysis by Francis Seton (1985) which gave the UK consistently the lowest eigenyields. The reasons for this are discussed in Chapter No 10.

A5.2.4: Eigenprice deviation

The deviation of industrial sector eigenprices for a given table give some indication of the distortion to the price structure brought about by subsidies and discriminatory indirect taxation. These are computed in a similar way to the RMS figures above as the root of the sum of squared deviations from unity.

$$Deviancy_{it} \quad = \quad \sqrt{\sum_{i=1}^{N} (f_{it} - 1)^2} \qquad (A5.3)$$

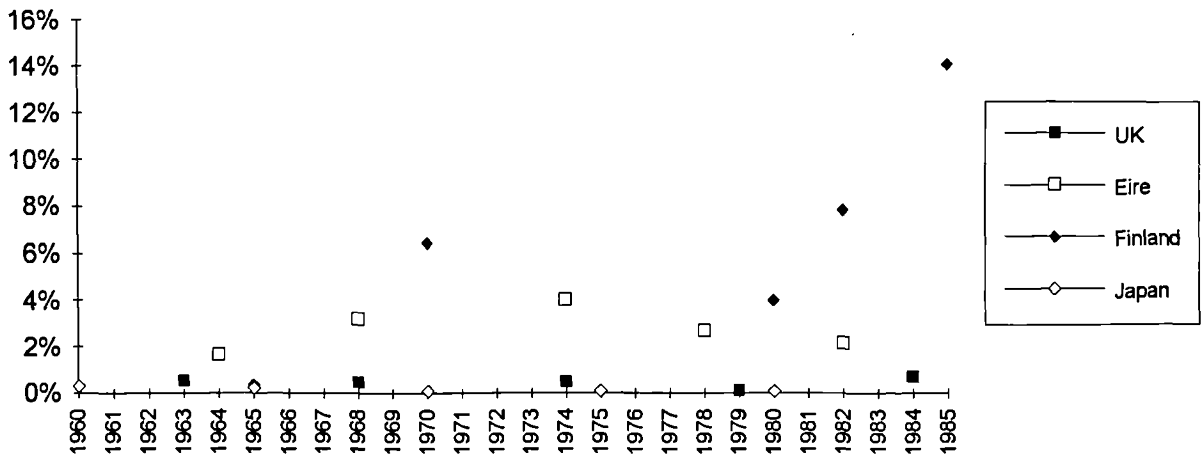

Figure A5.2.3: Eigenprice deviancy for factor inputs

Price deviancy for factor units are similarly calculated except that the factor eigenprices (n_{jt}) are used.

$$\text{Deviancy}_{kt} = \sqrt{\sum_{k=1}^{N} (n_{kt} - 1)^2} \qquad \text{(A5.4)}$$

The results are presented in Tables No 5.2.2 and 5.2.3. Eire displays high price deviancy for the industrial sectors but lower for the factor inputs. Finland shows rising trends in both. Japan and the UK both have low figures.

A5.2.5: Conclusions on results

The differences between the four countries are not that marked. This is not unexpected. First both the UK and Japan are island trading economies so the similarity in their prising structures might have been predicted.

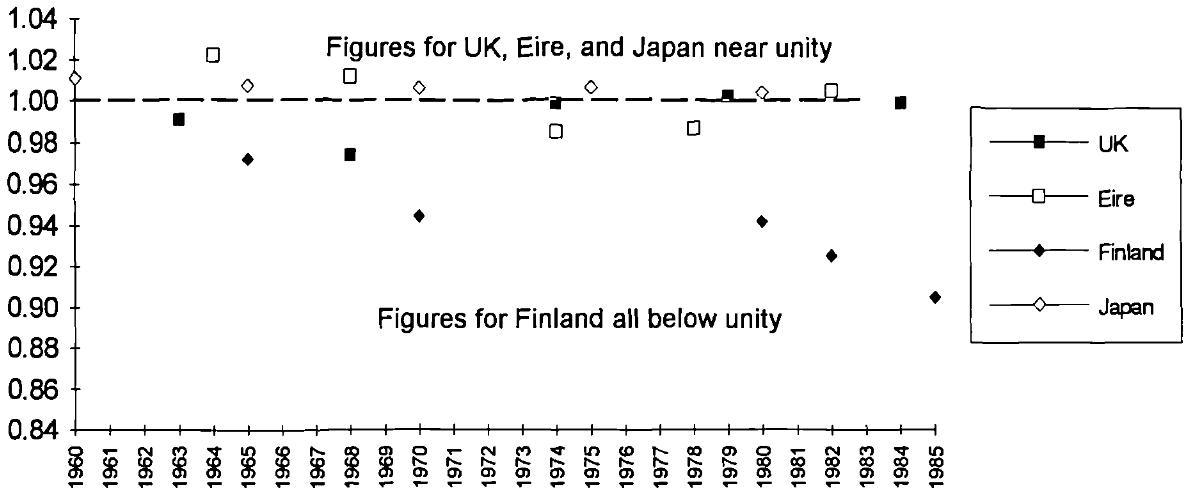

Figure A5.3.1: Eigenprices for Construction

Eire is a particular case in that its economy was very closely linked with that of the UK from the time of independence in the 1920s right through to the accession of both countries to the EC in the early 1970s. The partition of Ireland, into Northern Ireland (within the UK) and the Republic (Eire), left most of the industry in the north and an unbalanced agricultural economy in the south. Eire also remained part of the Sterling area with the pound as its currency until the advent of the ERM separated the Irish Punt from the Pound Sterling. It should not be surprising that the pricing structure of Eire was quite close to that of the UK at least in the earlier part of the study period.

Finland also had close trading relations with the UK when both were members of EFTA, although the UK's membership of the EC in recent years will have weakened these link. Finland had strong trading ties with the USSR before its dismemberment. It also has strong links with Nordic counties of Sweden, Norway and Denmark and evolved a similar welfare system. This may have contributed to the figures obtained.

The study shows that there are measurable differences in the eigenprice structures of the four countries although to obtain a clear distinction further study of countries such as Poland and Hungary might prove useful.

It now remains to examine the implications of this for the measurement of productivity in terms of international comparisons.

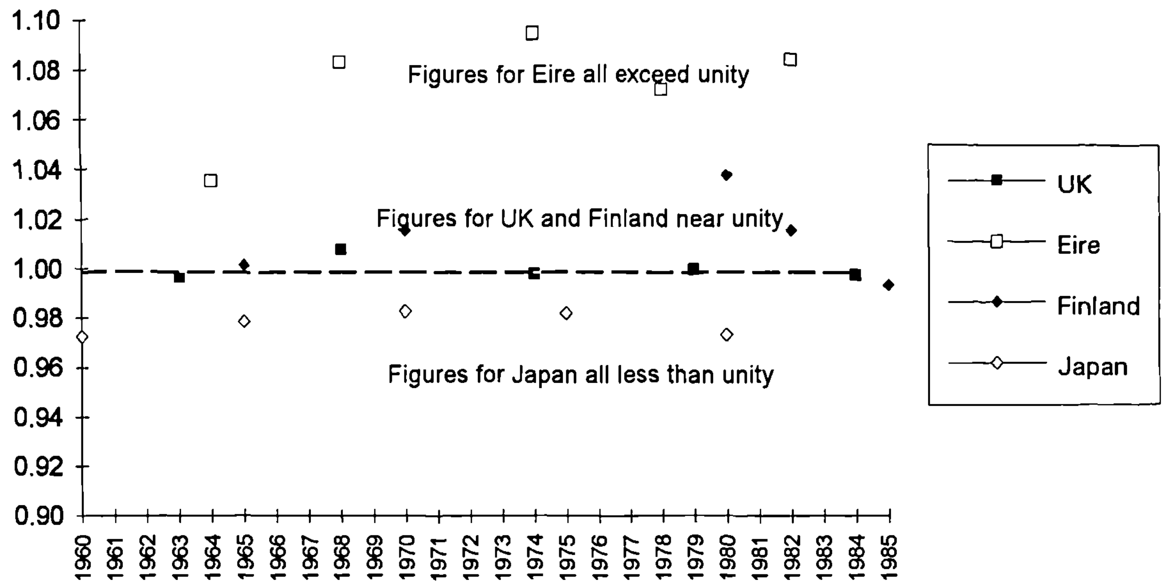

Figure A5.3.2: Eigenprices for Manufacturing

A5.3: Productivity measurement

The use made of eigenprices in the productivity measures included in the main Case Study, is to scale the price of capital asset inputs by the eigenprice of the source industry and to scale profit outputs by the eigenprice for profits. Working capital was scaled by eigenprice of the industry concerned. In the aggregated framework employed, manufacturing is the source of most fixed capital assets (vehicles, plant, and machinery) alongside construction (dwellings, real estate).

Thus, the only important eigenprices, from the viewpoint of productivity measurement are those for manufacture, construction, and profits. In a more disaggregated model there would be several different eigenprices required, corresponding the various categories of manufactured capital asset.

The eigenprices for construction or plotted against time and by county in Figure No A5.2.3. This shows figures near to unity for Japan and the UK. Finland has figures well below unity indicative of high taxation on the construction sector.

The graph for manufacturing are presented in Figure No A5.3.2. This again shows UK very near to unity. Japan is consistently below unity, this might reflect the nature of the Japanese economy where the efficient export-lead manufacturing sector helps to prop-up the inefficient service sector. Eire has figures well above unity indicative of subsidies to the manufacturing sector. Finland has similar, if less obvious trends.

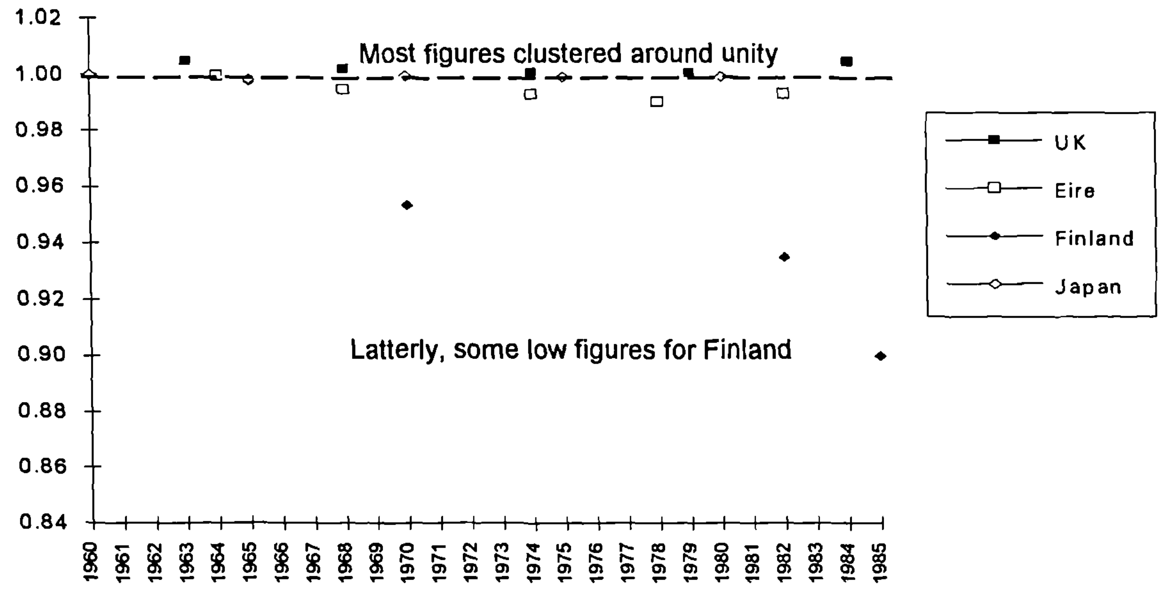

Figure A5.3.3: Eigenprices for Profits

The eigenprices for profits are plotted in Table No A5.3.3 below. This shows most eigenprices clustered around the unity line with Japan right on top, the UK slightly above and Eire slightly below. Only Finland has marked deviations from unity in this case.

It is not possible to carry the analysis further without full details of the capital matrices from the other countries. The results obtained here in the case of four quite similar market-based trading economies indicate that the productivity ratios would be affected by scaling in eigenprices although the differences would not be marked.

The method is unlikely to prove its worth unless it is being used to compare productivity in countries with markedly different economic structures, particularly those with unconvertible currency a heavy use of subsidies and discriminatory taxation.

APPENDIX NO 6:

OFFICIAL STATISTICS

GNP = Gross Naïve 'Proximation

Ralph Harris

A6.1: STANDARD INDUSTRIAL CLASSIFICATION

A6.1.1: Outline

Official statistics in the UK are currently published according to definitions included in the *Standard Industrial Classification* (SIC) 1980 Edition, (CSO, 1979). Previous editions were published in 1948, 1958, and 1968. The current edition is based on the General Industrial Classification of Economic Activities within the European Community (NACE).

Data are apparently collated in terms of industrial 'establishments' instead of by industries. Thus, each establishment will be classified according to its primary activity. If a firm operates at several different addresses, each of these may be classified as different establishments. Equally, if different activities are carried by distinct departments for which separate accounts are available, then each department may be classified as a distinct establishment.

This leads to a degree of 'under assessment' of construction works; construction tasks carried out in establishments whose main activity is not construction, will be omitted. Thus works divisions of enterprises – apart from those in central/local government or new town development authorities – will be classified to the parent industry instead of construction.

Equally, any repair and maintenance work carried out by the owner or occupier on a 'do-it-yourself' basis, will not be counted. Work carried out in an *off-site* prefabrication facility of a construction company, is excluded from construction, under the terms of the SIC. However, it is likely to be counted within the construction total unless the facility is deemed to be a separate establishment.

A6.1.2: Changes in the SIC

Some minor changes have been made to the SIC over the years; the principle effect on construction has been the omission of plant hire (without operatives) and open cast coal mining in the 1980 Revision.

Other changes include the consolidation of the utilities (gas, electricity and water) with coal mining to form the class 'energy and water supply'. Mining and quarrying, other than coal, now forms part of manufacturing. Also the growing significance of the services sector is gradually being recognised and more subdivision is now provided.

A6.2: CONSTRUCTION OF NATIONAL INCOME DATA

A6.2.1: Value added

This is calculated as part of the main economic aggregates. Estimates are taken using three different approaches. The first is based on 'final demand' using expenditure survey data. The second concentrates on 'income', and is largely derived from taxation data. The third is aimed at 'production' using surveys from the business community. The three estimates are compared and after allowance for an assumed rate of tax 'evasion', the difference between the income and expenditure based method is identified as the residual error. Figures for profit are derived from the above as a residual element after assessment of wages *etc.*

Little use is made of commodity flow methods in the estimation of national product and there is no real attempt at reconciliation of supply and demand at a detailed level in the national accounts (Lynch, 1988).

A6.2.2: Fixed capital investment

Fixed capital investment data is heavily reliant on information from the Annual Census of Production and Construction for the energy, manufacturing and construction industries. For the remainder of the economy it is generally based on the Annual (benchmark) Survey of Distribution and the Biennial survey of the Service industries. The above is summarized in the annual publication *Business Monitor* PA1001 from the Business Statistics Office of the Department of Trade and Industry.

It would appear that the figures exclude any fixed capital formation by the building and civil engineering departments of public sector agencies such as central government, local authorities, and public utilities. This omission is understandable given that for the vast majority of the period studied many such Direct Labour Organizations (DLOs) had accounts tangled up with those of the parent authority (Lowe, 1983). The amounts involved are unlikely to make a significant impact on the results. In any event, most of the DLOs tended to operate on a 'service department' basis. They were not expected to make profits other than to cover for reinvestment, leaving little surplus in the accounts to provide any real distortion in the figures.

Revaluation of investment figures is accomplished by means of a series of indices. For case of building works, the indexation is based on tender price movements lagged to reflect the delay between tender and commencement on site. Price fluctuation reimbursement approaches are also considered.

A6.2.3: Stockbuilding

The method of valuing the working capital used, varies from industry to industry. The assessment is in terms of the main stockholding industries instead of for SIC categories. Working capital can be split into three categories:

i) 'Materials and fuels' comprises materials and components used by each industry, but not incorporated into the finished product. Also included are fuels plus consumables held. In some industries, its value is measured using Census questionnaires, however for construction it is estimated. It would appear that from 1985 onwards, materials-on-site is included. Previously, only those materials and fuels that were stored *off-site* would be counted.

ii) 'Work-in-progress' covers the value of work completed or partially completed but not paid for. Again, for construction, it is estimated instead of being directly measured. These estimates are based on an assumption of a six-week lag between output and payment for contractual work. This assumption is reasonable given the method of interim payments used within the industry.

iii) 'Finished goods' comprise products completed but not sold. This clearly only applies to speculative work since contractual work will be deemed handed over on practical completion and, in any event, will have been largely paid for, *via* interim certificates. For construction, only speculative housebuilding is allowed for in the estimated value. The estimate is arrived at as the residual between the estimated output of the housebuilders and the estimates of sales. Unsold speculative industrial and commercial units are not covered.

The presentation of the estimated value of working capital causes problems since they are not given in the same SIC format as is used for value added and fixed investment data as indicated in Table 7.7.3. The main problem is that fishing, transport and communication, and non-central governmental services, appear to be included in a residual 'other industries' category. This begs the question of how it should be distributed. Given the relative insignificance of this residue (3.4% of total stocks for 1990), most of which is probably associated with transportation, it will make little difference.

For years before 1982, the 'residual' category includes construction, as well as the above, and consequentially is more significant in size (*e.g.* 10.0% in 1980). Before the 1959 *Blue Book*, the residual group included other industries such as wholesale distribution and is correspondingly more important (*e.g.* 24.8% in 1952). This leads to a more critical apportionment problem (see Appendix No 2).

A6.3: DERIVATION OF INPUT-OUTPUT TABLES

A6.3.1: Introduction

This presents a problem for the compiler of input-output tables since the input-output tables must be consistent with fully reconciled national account figures. Input-output tables are derived using census data adapted to conform with the basic national income data. The symmetrical industry-by-industry and commodity-by-commodity matrices, within the Input-output tables, which are used for the identification of industrial interdependencies are generally derived from the basic commodity-by-industry tables. In the UK, this is carried out in line with United Nations guidelines, using the following procedure. The starting point is the three basic tables:

a) The **make matrix**: this shows the output side of the economy in terms of the value of sales of each commodity by the industry responsible for its production. Commodities are represented by the rows of the matrix and industries by the columns. The principal products of each industrial group are given by the leading diagonal while secondary products are represented by other elements. All flows are shown in 'approximate basic values', in producers' prices *ex works*, less taxes net of subsidies.

b) The **absorption matrix**: this covers the input side with commodities produced in the U.K. as purchased by industries 'at current account'. This is also presented with commodities as rows and industries as columns. The intermediate flows are shown again at 'basic' prices with transportation costs and distributive margin shown as direct purchases of transportation and distribution respectively. In addition, value added and final demand is included in this table. Indirect taxes are treated as primary inputs and only the non-reclaimable element of VAT is included.

c) The **imports matrix**: this is given on a comparable basis to the absorption matrix and if the two are added, this will give the total flow matrix for the economy. Imports are valued on a 'balance of payments' basis. The re-exports shown in the tables are limited to those products readily identified because they are not produced domestically, *e.g.* rough diamonds.

The above tables were identified for the 1984 exercise using the following approach (Lynch, 1988) ¶. The rows were lined up with the income measure of national product as a control total with the columns similarly matched to the expenditure measure. The residual error was added to the profit row since this was deemed the most likely candidate for error.

The results of sales and purchase inquiries were classified to input-output group level, similarly import and export data were re-classified. The intermediate flows for the production industries were filled in using information from the Census of Production with information on energy uses and oil production. The reminder of the intermediate use table was estimated taking account of any enquiries in services and the transport/distribution industries.

The value added figures, obtained from tax returns *etc.*, were classified to the input-output groups. All transactions were adjusted to consumers prices by allowing for taxation and margins. Imports were then separated from domestic production.

Next, an approximate balance was obtained for each group between supply and demand, which was consistent with the control totals for input and for output. Finally the RAS method was applied for successive iterations to make the row and column totals match.

A6.3.2: Derivation of the symmetrical tables

The approach outlined here is presented in more detail within the 1968 Input-output tables for the UK and is summarized in subsequent tables published. The representation shown in Table A6.3.1 below has been changed from that used by the CSO to avoid conflicts with earlier notation.

The basic tables are represented thus in the model:

M = the transposed make matrix with elements m_{ij} representing the amount of commodity j produced by industry i [N X N].

U = the intermediate transactions part of the absorption matrix of elements u_{ij}, the requirements of domestically produced commodity i per unit output of industry j [N X N].

$\mathbf{U_M}$ = the intermediate transactions part of the imports matrix of elements u_{Mij}, the requirements of imports of commodity i per unit output of industry j [N X N].

The first step involves the calculation of the product mix matrix and the market share matrix thus:

¶ The approach used for the 1984 tables was probably more 'streamlined' than for previous benchmark tables and was accomplished by a comparatively small team fairly quickly. They relied extensively on microcomputer technology for the production of the tables.

$$\mathbf{G} = \mathbf{M}'\hat{\mathbf{Z}}^{-1} \qquad \text{(A6.1)}$$

$$\mathbf{S} = \mathbf{M}\,\hat{\mathbf{Q}}^{-1} \qquad \text{(A6.2)}$$

where **G** = *product mix matrix of elements* g_{ij} *each* representing the proportion of commodity i produced by industry j per unit of industry j output [N x N].

S = market share matrix of elements sij each representing the proportion of commodity j produced by industry i per unit of commodity output [N x N].

M' = make matrix - the *transpose* of the transposed matrix [N x N].

$\hat{\mathbf{Z}}^{-1}$ = inverse of diagonalized matrix with elements of industry output z_i on leading diagonal [N x N].

$\hat{\mathbf{Q}}^{-1}$ = inverse of diagonalized matrix with elements of commodity output q_i on leading diagonal [N x N].

The 'commodity-by-commodity' and the 'industry-by-industry' symmetrical matrices may be defined by assumptions of **commodity** technology or **industry** technology. The former would imply that one technology is appropriate for the production of each commodity regardless of the industry of production. The latter assumption would imply that a single technology was appropriate for each industry no matter what commodity is being produced. This arises due to the existence of secondary production, represented by the elements in the make matrix off the leading diagonal.

Thus, many industries including the energy and transportation groups carry out construction work as well as their primary products. The question relates to the selection of an appropriate input mix for such works — the construction *commodity* technology or the appropriate *industry* technology — for a given mix of output.

The commodity-by-commodity coefficient matrix can be derived thus:

	Commodities 1 2 3 4 5 6	Industries 1 2 3 4 5 6	Final demand C G I X	Total output
Commodities 1 2 3 4 5 6	*Commodity by commodity flow matrix* **T**	*Absorption matrix* **U**	*Final demand matrix* **J**	*Total output vector* **q**
Industries 1 2 3 4 5 6	*Make matrix transposed* **M**	*Industry by industry flow matrix* **X**	*Final demand matrix* **Y**	*Total output vector* **z**
Value Added M S W P T	*Primary input matrix* **W**	*Primary input matrix* **V**	**T**	
Total input	*Total input vector* **q'**	*Total input vector* **z'**		

Table A6.3.1: Input-output flows

$$\mathbf{E}_c = \mathbf{U}\,\mathbf{G}^{-1} \qquad \text{(A6.3)}$$

$$\mathbf{E}_I = \mathbf{U}\,\mathbf{S} \qquad \text{(A6.4)}$$

where $\mathbf{E}_c$ = commodity-by-commodity coefficient matrix of elements e_{ij} representing the purchase of commodity i used in the production of one unit output of commodity j on the assumptions of commodity technology [N x N].

$\mathbf{E}_I$ = commodity-by-commodity coefficient matrix on the assumptions of industry technology [N x N].

Industry-by-industry matrices can similarly be presented:

$$\mathbf{A}_c = \mathbf{G}^{-1}\mathbf{U} \quad \text{(A6.5)}$$

$$\mathbf{A}_I = \mathbf{S}\,\mathbf{U} \quad \text{(A6.6)}$$

where $\mathbf{A}_c$ = industry-by-industry coefficient matrix of elements a_{ij} on the assumptions of commodity technology [N x N].

$\mathbf{A}_I$ = commodity-by-commodity coefficient matrix based on industry technology [N x N].

In practice neither of the above assumptions is considered realistic and a blend of the two – hybrid technology assumptions – is employed for the production of input-output tables in the United Kingdom. This is accomplished by dividing the make matrix into two parts – one, comprising the elements for which the commodity technology assumption is more appropriate, and the other including those elements for which the industry technology assumptions are more suitable.

$$\mathbf{M} = \mathbf{M}_1 + \mathbf{M}_2 \quad \text{(A6.7)}$$

where $\mathbf{M}_1$ = transpose of part of make matrix for which commodity technology is suitable [N x N].

$\mathbf{M}_2$ = transpose of part of make matrix for which industry technology is suitable [N x N].

The product mix and market share matrices $\mathbf{G}_1$ and $\mathbf{S}_2$ can then be computed using $\mathbf{M}_1$ and $\mathbf{M}_2$ respectively. This will enable the hybrid technology matrix to be calculated thus:

$$\mathbf{H} = \mathbf{G}_1^{-1}\,[\,\mathbf{I} - \hat{\mathbf{S}}_2\,] + \mathbf{S}_2 \quad \text{(A6.8)}$$

where $\mathbf{H}$ = hybrid technology matrix [N x N]

$\hat{\mathbf{S}}_2'$ = diagonalized matrix with the column sums of $\mathbf{S}_2$ on the leading diagonal [N x N].

The symmetrical matrices on the assumptions of hybrid technology can be presented thus:

$$\mathbf{E}_{H} = \mathbf{U\,H} \tag{A6.9}$$

where $\mathbf{E}_{H}$ = commodity-by-commodity coefficient matrix on the assumptions of hybrid technology [N x N].

$$\mathbf{A}_{H} = \mathbf{H\,U} \tag{A6.10}$$

where $\mathbf{A}_{H}$ = industry-by-industry coefficient matrix on the assumptions of hybrid technology [N x N].

A worked example of the derivation of the symmetrical matrices using hybrid technology assumptions is included in Appendix No 1.

A6.3.3: Observations

It is conceded by the CSO that the approach used for the 1984 tables could easily lead to the production of an internally consistent table that did not reflect reality (Lynch, 1988):

> *There is a danger that setting up a method of compilation which will automatically produce balanced tables at the end of the day will result in insufficient attention being paid to the lessons of the real world. This can result in beautifully balanced tables consistent with national account totals, but reflecting industry structures which do not represent real life.*

The principal weakness concerns the determination of intermediate flows for those industries not covered by the Census of Production. Also, certain sectors have no statistical enquiry into purchases. In such cases Value Added Tax returns are the only real source of data, but have a weakness in that the record headings do not match the input-output groups. The issue of the identification of the output of the business services industry is now identified as a major problem by the CSO (Lynch, 1988).

APPENDIX NO 7:

DEFINITION OF SYMBOLS USED

Mathematics has no symbols for confused ideas

Anonymous

A7.1: Overall approach

A7.1.1: Introduction

Assigning symbols to represent the elements used in the model presented some problems in that there are in excess of 150 variables used in the model. There are around 150 equations, these are numbered within each Chapter. Thus, it is not easy to ensure that a given symbol is unique to each variable even on a 'local' (within Chapter) basis. To facilitate, this a standardized heirachy is used:

A7.1.2: Array variables

a) Matrices are presented **bold** in upper case *Helvetica* text thus: **A**.

b) Vectors (row or column) are presented **bold** in lower case *Helvetica* or *Symbol* text thus: **b** or $\boldsymbol{\pi}$

c) Diagonal matrices, *i.e.* a vector placed on the leading diagonal of a matrix with other elements zero, is presented **bold** in upper case with a 'hat' thus: $\hat{\mathbf{Y}}$.

d) Scalars are presented in lower case *Symbol* or *Helvetica* text thus: ϕ or *p*.

e) Elements of matrices and vectors are presented in lower case *Helvetica* text with subscripts thus: a_{ij} or z_i.

f) Dimensions of matrices or vectors are presented in SMALL CAPITALS *Helvetica* text thus: N.

g) Counters for arrays are presented in lower case *Helvetica* text along with the subscripts for the associated elements thus: i

Thus, the matrix **R** composed of elements r_{kj} will be of dimension [P X N] with P rows and N columns and subscripts k and j.

A7.1.3: Other variables

a) Other variables are presented in upper or lower case in *italics* in *Helvetica* or in *Symbol* text or initials thus: κ or L or GNP.

b) Parameters are preented in *Symbol* text thus: α or β

c) Functions are represented in *italics* by lower case *Helvetica* thus: $f(x)$ or$g(y)$

A7.2: Representation in detail

A7.2.1: Generally

$\sum_{i=1}^{N}$	=	summation of sequence from i = 1 to i = N
I	=	identity matrix
O	=	zero matrix
u	=	unit row vector [1,1, ... ,1] [1 x N] [1 x P]
N	=	number of industries used in the input-output schema *etc.*
M	=	number of categories of final demand
R	=	number of types of capital
P	=	number of different types of value added
Q	=	number of years of study
S	=	number of iteration in converging series
i	=	subscript variable for N rows of inter-industry matrix *etc.*
j	=	subscript variable for N columns of inter-industry matrix
k	=	subscript variable for P rows of value added matrix
l	=	subscript for M columns of final demand matrix
s	=	subscript variable for S iterations in converging series
t	=	subscript variable representing a given year t
$f(x)$	=	function of x
$g(y)$	=	function of y

A7.2.2: Chapters

Chapter 2: Productivity

θ	=	output
L	=	labour employed
π	=	profit
κ	=	capital invested
w	=	wage level
i	=	return on capital invested
ζ	=	cost function
χ_j	=	input j
y_j	=	cost of input j
s_j	=	cost share of input j
TFP_t	=	multi-factor productivity index for year t
ΔTFP_t	=	multi-factor productivity change for year t
A	=	constant of efficiency
α	=	distributional parameter for labour
β	=	distributional parameter for capital
t	=	time variable

Chapter 3: Capital Productivity

C	=	matrix of capital invested from year t to year (t-q+1) [N by Q]
D	=	matrix of capital depreciation from year t to year (t-q+1) [N by Q]
$\mathbf{k}_t$	=	column vector of capital stock in year t [N by 1]
$\boldsymbol{\delta}_{t-q}$	=	column vector of depreciation from year (t-q) to year t [Q by 1]
$\boldsymbol{\eta}$	=	column vector of price indices from year (t-q+1) to year t [Q by 1]
κ_{it}	=	capital stock category i in year t
η_{t-q}	=	scalar of price index for year (t-q) to t
η_t	=	price index from year (t-1) to year t
c_{it}	=	investment in category i in year t
κ_t	=	capital stock in year t
κ_{t-q}	=	capital stock prior to start of sequence
λ	=	discount rate
δ	=	depreciation rate
δ_i	=	depreciation rate for capital asset i
δ_j	=	composite depreciation rate for industry j
R_{iw}	=	return from capital asset i in year w
ρ_i	=	*per capita* return on capital asset i
ρ_j	=	overall rate of return on all capital invested in industry j
ν_i	=	growth of capital stock type i
κ	=	value of capital asset
L	=	labour employed
α	=	distributional parameter for labour
β	=	distributional parameter for capital
β_i	=	distributional parameter for [capital] asset type i
A	=	constant of efficiency
θ	=	value added income
$\tilde{a}_{it}$	=	average age of capital type i in year t
H_i	=	life of capital asset i

Chapter 4: Input-output productivity measurement

$\mathbf{X}$	=	matrix of intermediate flows x_{ij} of dimension [N x N]
$\mathbf{A}$	=	technical matrix of elements a_{ij} [N x N] (Demand side)
$\mathbf{B}$	=	allocation matrix of elements b_{ij} [N x N] (Supply-side)
$[\mathbf{I} - \mathbf{A}]^{-1}$	=	Leontief inverse matrix (demand-side) of elements g_{ij}.
$[\mathbf{I} - \mathbf{B}]^{-1}$	=	Leontief inverse matrix (supply-side) of elements h_{ij}
$\hat{\mathbf{Z}}^{-1}$	=	inverse of diagonal matrix of z_i [N x N]
$\mathbf{y}$	=	final demand column vector of elements y_i [1 x N]
$\mathbf{v}$	=	value added row vector of elements v_j [N x 1]
$\mathbf{z}_i$	=	gross output column vector of elements z_i [1 x N]
$\mathbf{z}_j^T$	=	transpose of gross input row vector [N x 1]
$\mathbf{z}_j$	=	gross input row vector of elements z_j [N x 1]
$\mathbf{z}_i^T$	=	transpose of gross output vector [1 x N]
x_{ij}	=	inter-industry flows from industry i to j.
a_{ij}	=	direct technical coefficients from industry i to j.
b_{ij}	=	direct allocation coefficients from industry i to j.
g_{ij}	=	flow from industry i to j per unit final demand i
h_{ij}	=	flow from industry i to j per unit value added j
y_i	=	final demand for industry i
y_{il}	=	final demand from category l and industry i
v_j	=	value added for industry j
v_{kj}	=	value added for factor k and industry j
z_i	=	gross output for industry i
z_j	=	gross input for industry j
ψ_i	=	total input multiplier for industry i
o_j	=	total output multiplier for industry j
φ_i	=	ratio of total output multiplier to total input multiplier
z	=	gross social product
GNP	=	gross national product
GNY	=	gross national income
GNE	=	gross national expenditure

Chapter 5: Time, Space, and Economic Systems

Q	=	matrix of primary-input factors of elements q_{kj} [P X N]
V	=	matrix of factor inputs (value added) of elements v_{kj} [P X N]
L	=	cost matrix of full (direct and indirect) costs for N products expressed in terms of P different factors of elements l_{kj} [P X N]
R	=	matrix of factor quota of elements r_{kj} [P X N]
$\mathbf{R}^{T}$	=	transpose of factor quota matrix [N X P]
N	=	factor norm matrix of elements n_{ik} [N X P]
$[\mathbf{I} - \mathbf{B}]^{-1T}$	=	transpose of supply-side Leontief inverse of elements h_{ij}
F	=	cost-norm matrix of elements f_{kh} [P X P]
P	=	norm-cost matrix of elements p_{ij} [N X N]
$\hat{\mathbf{Y}}$	=	diagonal matrix of final use totals with elements y_j [N X N]
$\hat{\mathbf{V}}^{-1}$	=	diagonal inverse matrix of final use totals v_k on leading diagonal [P X P]
$\hat{\mathbf{M}}$	=	diagonal matrix of final use as proportion of total output on leading diagonal [N X N]
τ	=	row vector of indirect taxes less subsidies [1 X N]
f	=	row vector of factor weightings [1 X N]
p	=	row vector of final use weightings [1 X N]
p (f)	=	row vector of total (uniformly marked up) costs when factors are valued at **f** [1 X P]
n (p)	=	row vector of factor-norms when final use products are valued at **p** [1 X N]
τ_j	=	indirect taxes less subsidies for industry j
σ	=	uniform 'mark-up' rate
ϕ	=	uniform cost/turnover ratio
q_{kj}	=	primary input factor
r_{kj}	=	proportion of value added for *jth* industry absorbed by the k*th* factor of production
v_k	=	value added for k*th* factor of production

Chapter 6: The Proposed Model

$\mathbf{K}_t$	=	capital matrix for year t [N x R]
$\mathbf{K}_c$	=	sub-matrix of capital — constructed facilities [N x 2]
$\mathbf{K}_m$	=	sub-matrix of capital — manufactured equipment [N x 8]
$\mathbf{K}_w$	=	sub-matrix of capital — working capital [N x 1]
$\mathbf{K'}_c$	=	sub-matrix of constructed facilities in eigenprices [N x 2]
$\mathbf{K'}_m$	=	sub-matrix of manufactured equipment in eigenprices [N x 8]
$\mathbf{K'}_w$	=	sub-matrix of working capital scaled into eigenprices [N x 1]
$\mathbf{K^*}_t$	=	total (input-output) capital matrix for year t [N x R]
$\mathbf{K'}$	=	total capital matrix scaled into eigenprices
$\hat{\mathbf{D}}'$	=	diagonal matrix to represent depreciation with elements $(1\text{-}d_{it})$ on leading diagonal [R x R]
$\hat{\mathbf{P}}$	=	diagonal matrix consisting of the elements of the vector **p** on leading diagonal [R x R]
$\hat{\mathbf{K}}^{*-1}$	=	inverse of diagonal matrix with elements of $\mathbf{k}^*_j$ on leading diagonal [N x N]
$\mathbf{k}_{jt}$	=	column vector of capital for industry j in year t [1 x R]
$\mathbf{k}^*_{jt}$	=	row vector of total capital in each industry in year t [1 x N]
$\mathbf{c}_{jt}$	=	column vector of investment for industry j in year t [1 x R]
$\mathbf{w}$	=	column vector of 'value added' by income type [P x 1]
$\mathbf{v}_k$	=	direct profit row vector corresponding to the *kth* row of **V** [1 x N]
δ_i	=	row vector of depreciation rates for each capital type i [1 x N]
δ_j	=	row vector of composite depreciation rates for industry j [1 x N]
γ	=	row vector of total return on capital for each industry j [1 x N]
λ	=	row vector of discount rate for each industry j [1 x N]
π	=	total (input-output) profit row vector [1 x N]
π'	=	total (input-output) profit row vector in eigenprices [1 x N]

Chapter 6: The Proposed Model (Cont.)

ω_t	=	working capital column vector for year t [N x 1]
κ^*_{ij}	=	total capital type i invested in industry j
δ_i	=	depreciation rate for capital type i
δ_j	=	composite depreciation rate for industry j
γ_j	=	overall rate of return on all capital invested in industry j
λ_j	=	discount rate for industry j
$(1/v)$	=	scalar of reciprocal of total value added
η_t	=	scalar of price index movements from year t-1 to year t
δ_{it}	=	scalar of depreciation for capital category i in year t
p_c	=	scalar of the element of the eigenprice vector for construction
p_m	=	scalar of the element of the eigenprice vector for manufacture
f_k	=	scalar of eigenprice for profits

Chapter 8: Implementation

$\mathbf{E}_H$	=	commodity-by-commodity coefficient matrix on assumptions of hybrid technology [N x N].
$\mathbf{A}_H$	=	industry-by-industry coefficient matrix on assumptions of hybrid technology [N x N].
U	=	intermediate transactions part of absorption matrix [N x N].
H	=	hybrid technology matrix [N x N].

Chapter 9: Reliability of results

$\lvert\delta x\rvert$	=	absolute error
x	=	computed solution
x	=	actual solution
ε_x	=	absolute error bound
r_x	=	relative error
ρ_x	=	relative error bound

Appendix No 6: Official Statistics

M	=	the transposed Make matrix with elements m_{ij} representing the amount of commodity j produced by industry i [N x N].
U	=	the intermediate transactions part of the Absorption matrix of elements u_{ij}, the requirements of domestically produced commodity i per unit output of industry j [N x N].
$\mathbf{U}_M$	=	the intermediate transactions part of the imports matrix of elements tij the requirements of imports of commodity i per unit output of industry j [N x N].
G	=	product mix matrix of elements g_{ij}, each representing the proportion of commodity i produced by industry j per unit of industry j output [N x N].
S	=	market share matrix of elements s_{ij} each representing the proportion of commodity j produced by industry i per unit of commodity output [N x N].
M'	=	make matrix - the *transpose* of the transposed matrix [N x N].
$\mathbf{E}_C$	=	commodity-by-commodity coefficient matrix of elements e_{ij} representing the purchase of commodity i used in the production of one unit output of commodity j on the assumptions of commodity technology [N x N].
$\mathbf{E}_I$	=	commodity-by-commodity coefficient matrix on the assumptions of industry technology [N x N].
$\mathbf{A}_C$	=	industry-by-industry coefficient matrix of elements a_{ij} on the assumptions of commodity technology [N x N].
$\mathbf{A}_I$	=	commodity-by-commodity coefficient matrix based on industry technology [N x N].
$\mathbf{E}_H$	=	commodity-by-commodity coefficient matrix on assumptions of hybrid technology [N x N].
$\mathbf{A}_H$	=	industry-by-industry coefficient matrix on the assumptions of hybrid technology [N x N].

Appendix No 6: Official Statistics (Cont.)

$\mathbf{M_1}$	=	transpose of part of Make matrix for which commodity technology is suitable [N x N].
$\mathbf{M_2}$	=	transpose of part of Make matrix for which industry technology is suitable [N x N].
$\mathbf{H}$	=	hybrid technology matrix [N x N]
$\hat{\mathbf{Z}}^{-1}$	=	inverse of diagonalized matrix with elements of industry output z_i on leading diagonal [N x N].
$\hat{\mathbf{Q}}^{-1}$	=	inverse of diagonalized matrix with elements of commodity output q_i on leading diagonal [N x N].
$\hat{\mathbf{S}}_2'$	=	diagonalized matrix with the column sums of $\mathbf{S_2}$ on the leading diagonal [N x N].